Reaching the U.S. Fire Service with Hydrogen Safety Information: A Roadmap

Part 1: Fire Service Primer
Part 2: Permitting Roadmap and Incident Response Protocol
Part 3: Emergency Responder Training Needs

Final Report

A Report for:
National Renewable Energy Laboratory
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FOREWORD

This study provides an overview of the U.S. Fire Service to help improve the transfer of hydrogen safety information to and from the emergency response community. The fire service in the United States involves numerous individuals and organizations, and the information included in this report provides a better understanding of emergency first responders to facilitate efficient and effective transfer of hydrogen safety information.

This report is a compendium of the following three parts that comprise this study:

- Part 1: Fire Service Primer (a detailed primer that provides an overview of the Fire Service in the United States);
- Part 2: Permitting Roadmap and Incident Response Protocols (an overview of permitting and incident response, with details for purposes of illustration of six specific case study jurisdictions); and
- Part3: Emergency Responder Training Needs (an overview and summary of training needs for applications involving hydrogen-based applications such as road vehicles, rail vehicles, industrial lift trucks, fixed sites, etc).

This project has involved significant input from a wide range of individuals. Special thanks are extended to the U.S. Department of Energy and National Renewable Energy Laboratory who have funded this project and made it possible. Appreciation is likewise extended to the Project Technical Panel for their helpful guidance and assistance, and to the numerous individuals and organizations that have monitored and/or participated in the project by providing valuable input.

The content, opinions and conclusions contained in this report are solely those of the author.

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EXECUTIVE SUMMARY

The Fire Service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. The infrastructure for decision making and for communication varies from jurisdiction to jurisdiction (state, city and region across the country) and by multiple other factors.

There are three deliverables for this project. The first deliverable (Part 1) is a detailed primer that provides an overview of the Fire Service in the United States. The second deliverable (Part 2) includes a permitting roadmap and incident response protocols for six specific case study jurisdictions located in the United States. The third (Part 3) is a summary of first responder stated training needs for applications involving hydrogen-based applications (e.g. road vehicles, rail vehicles, industrial lift trucks, fixed sites, etc).

This study seeks to improve the transfer of hydrogen infrastructure safety information to and from the fire service. In particular, this report provides a roadmap of regulatory permitting and fire service emergency response, and focuses on applicable new hydrogen based applications including hydrogen refueling stations and hydrogen back-up power installations (e.g. at telecommunications facilities).

This initiative is funded through the U.S. Department of Energy and the National Renewable Energy Laboratory, and thus the geographic focus is primarily the United States. Some fire service organizations exist and operate independent of national boundaries, and thus reference to activities in other countries (e.g. Canada) are included to the extent that they are applicable.

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REACHING THE U.S. FIRE SERVICE WITH HYDROGEN SAFETY INFORMATION: A ROADMAP

FIRE SERVICE PRIMER

Part 1 of 3

A Report for:

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1) PART 1: INTRODUCTION AND BACKGROUND

The U.S. Department of Energy (DOE) is developing a comprehensive suite of information related to safety in the infrastructure supporting hydrogen energy sources for commercial implementation. The U.S. fire service is an important audience for this information, both as it relates to safety considerations in design and permitting of constructed facilities, and safety considerations related to incident response.

The goal of this project is to improve the transfer of hydrogen safety information to the fire service. The fire service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. This effort will provide an overview of the U.S. fire service and information as to how to communicate with the U.S. fire service in key jurisdictions.

This effort intends to provide a roadmap overview of the U.S. Fire Service, as well as information for facilitating communications with the U.S. Fire Service in key jurisdictions. The infrastructure for decision making and for communication varies from jurisdiction to jurisdiction (state, county, city and region across the country) and by multiple other factors. Working with the multiple jurisdictions is important to help implement the on-going programs required to enable more widespread hydrogen usage.

Three specific tasks comprise the main deliverable of this overall project report, all with a focus on hydrogen-based applications including but not limited to the direct commercial implementation of hydrogen refueling stations and hydrogen back up power installations for telecommunications. The first task (this section, i.e. Part 1), involves developing a detailed primer that provides an overview of the Fire Service in the United States. The second task (Part 2) is to generate permitting roadmaps and incident response protocols, supplemented with examples provided by six case study jurisdictions. The third task (Part 3) is to summarize first responder preferred training needs for applications involving hydrogen-based applications (e.g. road vehicles, rail vehicles, industrial lift trucks, fixed sites, etc).

Specifically, report Part 1 develops a detailed primer on the structure of the Fire Service in the United States, both from the fire prevention and emergency response perspectives, which describes jurisdictional boundaries, variation by type of facility, typical responsibilities, and key organizations. This primer clarifies the overall infrastructure of the authorities having jurisdiction (AHJs) in the United States, including AHJs that operate by legislative mandate (e.g. fire inspectors, building officials, etc) and those that do not (e.g., insurance industry, etc). The primer also includes a special section on fire service member organizations and proven effective education and communication methods.

2) Overview of Hydrogen and Hydrogen Safety

The use of alternative fuels in today's society is increasing due to economic and regulatory influences. Among these alternative fuels, hydrogen has certain positive characteristics that make it a desirable replacement for conventional hydrocarbon fuels.

Hydrogen is widely recognized as a suitable and ideal fuel for a range of applications, but it is equally recognized for its hazard characteristics. The dangers associated with hydrogen, both real and perceived, need to be properly considered if it is to become widely used as a fuel and energy carrier. An energy carrier is a substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes.[1]

This section provides an overview of hydrogen and the safety issues that are of concern and interest to fire safety professionals. This includes a review of its physical properties, hazard identification, loss history, current and future applications, and available resources supporting the hydrogen safety infrastructure. Detail provided on this issue is considered to be of most interest to permitting officials and emergency first responders.

Physical Properties of Hydrogen

Hydrogen is the most abundant element in the universe and makes up about 80 percent of common stars.[2] However, in its natural state on Earth it does not exist as a pure substance but instead is found in compounds with other elements. Virtually all hydrogen used by today's civilization is generated by reforming other compounds to separate out the hydrogen.[3]

At room temperature and pressure it is the lightest known gas. It is colorless, odorless, tasteless, flammable, and nontoxic, and is approximately 14 times lighter than air.[4] The expansion ratio of hydrogen liquid to gas is 1:848, meaning that if a cubic foot of liquid hydrogen was released to the atmosphere, it would expand to 848 cubic feet of gas.

All substances can exist as gases, depending on the temperature and pressure applied to them, and for discussion herein the term *gas* is applied to substances that exist in a steady gaseous state at NTP - Normal Temperature and Pressure. This condition is considered to be approximately 20°C (68°F or 293°K) and 1 atmosphere (101.3 kPa, 14.7 psia, or 0 psig).[5]

Hydrogen contains more useful energy per pound than any other readily available fuel, and for air or ground transportation it is more efficient on a weight basis than other fuels.[6] All common fuels in our world today, whether solid, liquid, or gaseous, are based on the element carbon along with significant proportions of hydrogen. Hydrogen is similar to certain substances such as methyl alcohol, in that it does not produce soot when it burns and thus has non-luminous

flames that are invisible to the naked eye in normal daylight. It has an extremely wide flammable range and the highest burning velocity of any gas. Its ignition energy is very low, though its ignition temperature is reasonably high.

For conventional use hydrogen is transported and handled as either a flammable (compressed) gas or a flammable (cryogenic) liquefied gas. These are the two primary storage methods. The terms *flammable gas* and *flammable liquefied gas* are defined in NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks* as follows:[7]

> *Flammable Gas. A material that is a gas at 20°C (68°F) or less at an absolute pressure of 101.325 kPa (14.7 psia), that is ignitable at an absolute pressure of 101.325 kPa (14.7 psia) when in a mixture of 13 percent or less by volume with air, or that has a flammable range at an absolute pressure of 101.325 kPa (14.7 psia) with air of at least 12 percent, regardless of the lower limit.*
>
> *Flammable Liquefied Gas. A liquefied compressed gas that, when under a charged pressure, is partially liquid at a temperature of 20°C (68°F) and is flammable.*

A summary of hazardous chemical data for hydrogen is illustrated in Table 1-1, as compiled in NFPA 49, Hazardous Chemicals Data (1994 edition, amended in 2001). This information provides helpful guidance on storage and fire fighting techniques for use in disaster planning or in an emergency, though it is not intended for workplace exposure or for relative indices of toxicity.[8]

As clarification on terminology, a certain form of hydrogen may be referred to by the chemical name “protium” (also called hydrogen-1 or light hydrogen). Protium is the most abundant isotope of the element hydrogen (an isotope is an element that has the same atomic number but different mass number, and put simply, have the same number of protons but a different number of neutrons). Protium is a stable isotope meaning that it is not radioactive, and has one proton, no neutrons and an atomic mass of 1. Otherwise, hydrogen in its normal state as an electrically neutral atom contains a single positively-charged proton and a single negatively-charged electron bound to the nucleus.[9] At NTP (normal temperature and pressure), hydrogen commonly exists in diatomic form as two covalently bonded hydrogen particles that each share one electron. This is written as H_2.

A common intuitive approach used by permitting officials and emergency first responders when evaluating less familiar hazardous materials is to compare them against more common and better understood hazardous materials. Conveniently, the literature includes multiple sources that compare the reactivity and damage potential properties of hydrogen with methane, which is the primary component in natural gas, and with gasoline. Table 1-2 provides a comparison of the properties of hydrogen, methane and gasoline.

When compared to other conventional and widely available gaseous fuels like methane, hydrogen has certain flammability characteristics that are more hazardous and some that are less hazardous. In general these characteristics offset and depend on multiple factors associated with a particular accident scenario, recognizing that the technical characteristics of a gas explosion depend on multiple factors.[22]

Table 1-1: Basic Hazardous Chemical Data for Hydrogen [10, 11, 12, 13, 14, 15]

NAME	**Hydrogen, refrigerated liquid**	**AUTOIGNITION TEMPERATURE**	400°C (752°F)
SYNONYMS	protium	**FLAMMABLE LIMITS**	4.0% - 75.0%
FORMULA	H_2	**MELTING POINT**	-259°C (-434°F)
DOT CLASS	Class 2.1 Flammable Gas	**BOILING POINT**	-253°C (-423°F)
SHIPPING LABEL	FLAMMABLE GAS	**SPECIFIC GRAVITY**	0.071
ID NUMBER	UN 1966 refrigerated liquid	**WATER SOLUBILITY**	not soluble
CAS NUMBER	1333-74-0	**VAPOR DENSITY**	0.069
MOLECULAR WEIGHT	2.0	**VAPOR PRESSURE**	gas

STATEMENT OF HAZARD	Liquefied or compressed flammable gas. Low ignition energy. Burns with practically invisible flames. Reacts vigorously with oxidizers.
EMERGENCY RESPONSE PERSONAL PROTECTIVE EQUIPMENT	Wear special* protective clothing and positive pressure self-contained breathing apparatus. (* "Special" would be, for example, in accordance with NFPA1991, *Standard on Vapor-Protective Ensembles for Hazardous Materials Emergencies* 2005 edition, NFPA 1992, *Standard on Liquid Splash-Protective Ensembles and Clothing for Hazardous Materials Emergencies* 2005 edition, or NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents* 2007 edition)
SPILL OR LEAK PROCEDURES	Eliminate all ignition sources. Approach release from upwind. Stop or control the leak, if this can be done without undue risk. Use water spray to disperse vapors and protect personnel.
FIRE FIGHTING PROCEDURES	Approach fire with caution as high-temperature flame is practically invisible. Stop flow of gas before extinguishing fire. Use water spray to keep fire-exposed container cool. Use flooding quantities of water as fog/spray.
HEALTH HAZARDS	Contact with liquid will cause frostbite or severe burns of the skin. Simple asphyxiant.
FIRE AND EXPLOSION HAZARDS	Liquefied or compressed flammable gas. Easily ignited over a wide range of vapor/air concentrations. Rapid propagation of flame or flashback possible. Burns with practically invisible flame at 2038°C (3700°F), which must be avoided. Flammable or explosive when mixed with chlorine or other oxidizing materials. Liquid hydrogen in exposed piping may condense oxygen out of atmosphere. High pressure releases often ignite with no apparent source of ignition possibly via static electricity.
INSTABILITY AND REACTIVITY HAZARDS	Easily oxidized. Some steels are susceptible to hydrogen attack or embrittlement at high temperature and pressure.
STORAGE RECOMENDATIONS	Store in a cool, dry, well-ventilated location. Outside or detached storage is preferred. Isolate from oxygen, halogens, and other oxidizing materials.
USUAL SHIPPING CONTAINERS	Cylinders and special tank cars
PHYSICAL PROPERTIES	Colorless, odorless gas. Much lighter than air.
ELECTRICAL EQUIPMENT	Class I, Group B

For example, certain hydrogen characteristics relative to other common fuels are less hazardous, such as it generates less severe radiant energy to adjacent exposures, and it disperses rapidly when not confined and outdoors. However, in contrast hydrogen explosions produce generally higher over-pressures in partially-confined or vented areas, will more readily ignite from electrostatic discharges or sparks, and will more likely leak from an airtight storage vessel.[23]

Table 1-2: Comparison of the Properties of Hydrogen, Methane and Gasoline [16, 17, 18, 19, 20, 21]

PROPERTY[1]	HYDROGEN (H_2)	METHANE[2] (NATURAL GAS - CH_4)	GASOLINE[3]
Physical state at 25°C (at 1 atm)	Gas	Gas	Liquid
Molecular weight	2.02	16.0	107
Normal boiling point (at 1 atm)	-253°C (-423°F)	-162°C (-259°F)	37°C (98°F) to 205°C (401°F)
Buoyancy (density as a % of air)	7	55	400
Specific gravity at 300°K (27°C, 80°F), air=1	0.0696	0.641	3.7
Density of vapor (at NBP)	0.00134 g/cm^3	0.00182 g/cm^3	0.0045 g/cm^3
Density of gas (at NTP)	84 g/m^3	651 g/m^3	4400 g/m^3
Diffusion coefficient in air	0.61 cm^2/sec	0.16 cm^2/sec	0.05 cm^2/sec
Flammability range in air [volume %]	4.0 - 75	5.3 - 15	1.0 - 7.6
Stoichiometric concentration (%)	30	9.5	1.8
Heat of combustion[4]	120 KJ/g	50 KJ/g	44.5 KJ/g
Ignition temperature	585°C (1085°F)	540°C (1004°F)	228°C (442°F) to 471°C (880°F)
Minimum ignition energy in air (at 1 atm)	0.02 MJ	0.29 MJ	0.24 MJ
Flame temperature in air[5]	2045°C (3713°F)	1875°C (3407°F)	2197°C (3986°F)
Relative thermal radiation	10 %	33 %	50 %
Minimum quenching distance	0.6 mm	1.2 mm	2.8 mm
Maximum flame speed	3.2 m/sec	0.4 m/sec	0.5 m/sec
Maximum overpressure ratio	8.4	7.7	5.1
Maximum explosion overpressure	125 psi	110 psi	75 psi
Lower Detonation Limit	18 %	6 %	1 %
Upper Detonation Limit	59 %	14 %	3 %
Lower calorific mixture value	2.9 MJ/m^3	3.1 MJ/m^3	4.5 MJ/m^3
TNT equivalent of fuel	1	0.42	0.38

Table Footnotes:

1 Values in table are approximatations for the purpose of comparison.
2 Methane is the major constituent of most compressed natural gases and of liquefied natural gas (LNG).
3 Based on average arithmetic values for normal heptanes and octane.
4 Heat of Combustion is the energy, per gram of fuel, generated by a combustion reaction, with all of the water formed by combustion a vapor.
5 Based on experimentally determined flame temperatures.

In summary, for safety professionals the hazard characteristics of a hydrogen storage facility are comparable to those involving other conventional fuels that are more commonly found in today's society (e.g. natural gas or gasoline). Rapid gas dispersion and certain other characteristics of hydrogen are beneficial, but at the same time a conservative approach will be

sensitive to factors such as the more extensive flammability range of hydrogen, as well as the relatively low energy level (e.g. small spark) required to initiate hydrogen combustion at its optimal combustion conditions of approximately 30% hydrogen-to-air volume ratio.[24]

Hazard Identification

Hydrogen has been used as a fuel or ingredient in certain processing applications for decades.[25] Its use by industry and elsewhere (such as the medical and research communities) has resulted in moderate quantities being shipped by truck or rail as part of interstate commerce. As such, it is a relatively typical hazardous material that might be encountered by an emergency responder at many typical emergency events.

Hydrogen is considered a hazardous material due primarily to its flammable and explosive properties (flammable range of 4 – 75 % in air, and detonation limits of 18 – 59 % in air), and thus it requires placarding or signage for any bulk transport on public venues. Hydrogen is classified as flammable, compressed or cryogenic.[26] Examples of the different placards required are illustrated in Figures 1-1 through 1-4.

Specifically, Figure 1-1 illustrates the placards required for bulk transport of hydrogen as a compressed gas or a cryogenic liquid.[27] The two placards on the left of Figure 1-1 are for transport of compressed hydrogen, and they use the UN (United Nations) identification number of 1049. The two placards on the right of Figure 1-1 are for the transport of hydrogen as a cryogenic liquid, and this uses UN identification number 1966. In the United States these placards are required by federal law for bulk transport of hydrogen; they are also used for other applications such as fixed sites, even though not mandated.

Figure 1-1: U.S. Department of Transportation Placards for Gaseous and Liquefied Hydrogen [28]

Additional placarding is shown in Figure 1-2, which illustrates placards recommended for hydrogen identification according to the diamonds prescribed by NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*.[29] This indicates that hydrogen (as a compressed gas or as a cryogenic liquid), has a flammability classification of 4 (out of 4) which is assigned to the most flammable substances. Otherwise, hydrogen has low classification in terms of reactivity and toxicity, although as a cryogenic liquid it has reactivity concerns inherent to any cryogenic liquid. These placards are not required by federal mandate, and as such their use is contingent on adoption by a particular local jurisdiction.

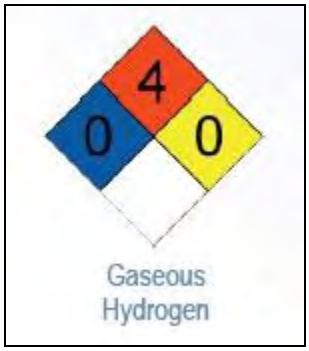

Figure 1-2: NFPA 704 Diamond Placards for Gaseous and Liquefied Hydrogen (colored diamonds signify: blue = health hazard; red = flammability hazard; yellow = instability hazard; and white = special hazard) [30]

Aside from placarding as shown in Figures 1-1 and 1-2, several other placards and signs can be found associated with the transport and use of hydrogen. This includes the descriptive warning signs in Figure 1-3, for either gaseous or liquefied hydrogen.[31] These placards are not required by federal mandate, although they may be found supplementing other placards mandated for transport, storage or use. Also, Figure 1-4 is a blue diamond used as a small decal recommended by the Society of Automotive Engineers (SAE) to be attached to the rear corner of vehicles powered by compressed hydrogen.[32] This feature allows first responders to better identify possible hazards at motor vehicles accidents and fires.

Figure 1-3: Warning Placards for Gaseous and Liquefied Hydrogen [33]

Figure 1-4: Blue Diamond Symbol for Compressed Hydrogen [34]

A key reference publication used by emergency first responders for hazardous materials in the United States is the "Emergency Response Guidebook". This publication is provided free of charge by the U.S. Department of Transportation and its circulation is very widespread among U.S. fire service emergency first responders.[35] It is mentioned here since it is familiar to most fire service personnel responding to an incident involving hydrogen. The Guidebook recognizes the following five states/conditions: (1) hydrogen; (2) hydrogen absorbed in metal hydride; (3) compressed hydrogen; (4) hydrogen in a metal hydride storage system; and (5) hydrogen as a refrigerated liquid (cryogenic liquid). Table 1-3 indicates the UN identification number and guide number for each of these states/conditions. In all cases, it's noted that the guideline used for addressing a hazardous materials incident involving hydrogen, in any state or condition, is "Guide 115". Emergency first responders should thus focus on this two page guideline (i.e. Guide 115) when addressing an incident involving hydrogen.

Table 1-3: Summary of Hydrogen Addressed by the Emergency Response Guidebook [36]

STATE / CONDITION	UN IDENTIFICATION NUMBER	GUIDE NUMBER
(1) Hydrogen	1049	115
(2) Hydrogen absorbed in metal hydride	9279	115
(3) Compressed hydrogen	1049	115
(4) Hydrogen in a metal hydride storage system	3468	115
(5) Hydrogen as a refrigerated liquid (cryogenic liquid)	1966	115

Historical Loss Summary

The most directly applicable and updated information on loss information addressing incidents involving hydrogen is available from "H2 Incidents", a website operated on behalf of the U.S. Department of Energy at www.h2incidents.org. This provides useful and important information for fire safety professionals to better understand the hazards associated with hydrogen. The H2 Incidents on-line database is illustrated in Figure 1-5.[37]

The H2 Incidents database is similar to the "National Fire Fighter Near-Miss Reporting System" that is widely used among the U.S. fire service (at www.firefighternearmiss.com), and likewise has a focus on incidents and near-misses with ensuing lessons learned from those events.[38] Both database systems allow a user to submit an incident, and identifying information is removed before incidents are posted.

Additional possible data sources with large data collection efforts with some applicability toward hazardous materials include:

- CSB: U.S. Chemical Safety and Hazard Investigation Board, section on completed investigations, available at: www.chemsafety.gov.
- FIDO: Fire Incident Data Organization, administered by NFPA's One Stop Data Shop provides information on large fires and fires of major technical interest, available at: www.nfpa.org.
- NFIRS: The National Fire Incident Reporting System, administered by the U.S Fire Administration used to develop national estimates of specific fire problems, available at: www.nfirsonline.com.
- NTSB: U.S. National Transportation Safety Board, section on major investigations and investigation reports, available at: www.ntsb.gov.

- OSHA: U.S. Department of Labor Occupational Safety & Health Administration, section on Accident Investigations, available at: www.osha.gov/pls/imis/accidentsearch.html.
- PHMSA: U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration Incident Reporting System, used for the reporting of hazardous materials incidents in accordance with U.S. federal regulations in 49 CFR 171.15 and 171.16, available at: www.phmsa.dot.gov/hazmat/incident-report.

Figure 1-5: Illustration of the DOE "H2 Incidents" On-Line Database.[39]

For example, a review of the U.S. DOT PHMSA Incident Report website for "Hydrogen" as defined by the US DOT identification number of "UN1049" reveals fourteen reported vehicle-related incidents involving highway transport. These occurred in ten different states during an 8-year time frame ending in March 2009. Compressed gaseous hydrogen was involved in each and the containers ranged from small portable compressed-gas cylinders to large tube trailers. The following details apply to these 14 incidents, which illustrates the detail that can be extracted from this data:[40]

- 6 occurred during unloading and 8 while in transit;
- 9 involved gas dispersion and 5 did not;
- 4 had a resulting fire and 10 did not;
- none resulted in environmental damage;
- 4 required evacuation;
- 1 required a major artery to be closed;
- 2 involved a vehicle overturning and 2 involved a vehicle leaving the roadway; and
- 1 resulted in a fatality, and 4 injuries occurred;

Additional loss information is available from selected sources, although these are typically focused on specific narrow ranges of applications. For example, a 1978 report generated by

Factory Mutual Research Corporation summarizes industrial oriented losses from 1965 through 1977 that may be of interest, and utilizes loss data not only from their own records but multiple other industrial and specialized organizations and agencies (e.g., API, U.S. NASA, U.S. NRC, etc).[41] In this case the focus is not mainstream consumer use, but instead industrial and specialized applications like: ammonia synthesis, oil refining, methanol synthesis, hydrogenation of fats/oils, production of metal ores, rocket propellant, electric motor cooling, electronics processing, and miscellaneous chemical processes.

Resources Supporting the Hydrogen Safety Infrastructure

Safety professionals have significant resources and information readily available to assist in addressing the topic of hydrogen. This includes useful information that describes the general properties and characteristics of hydrogen, as well as detailed information on its production, delivery, storage and use. A significant amount of this information is web-based and thus readily accessible. Table 1-4 provides a summary of some of this information and is provided for the convenience of fire safety professionals.

Table 1-4: Useful Web-Based Sources for Hydrogen Information for Safety Professionals

ORGANIZATION / SITE TITLE	WEB SITE URL
U.S. Department of Energy	
Energy Efficiency and Renewable Energy	www1.eere.energy.gov/hydrogenandfuelcells/
H2 Best Practices	www.h2bestpractices.org/
H2 Incident Reporting and Lessons Learned	www.h2incidents.org/
Hydrogen Analysis Resource Center	hydrogen.pnl.gov/cocoon/morf/hydrogen
Hydrogen Safety Bibliographic Database	www.hydrogen.energy.gov/biblio_database.html
National Renewable Energy Laboratory	www.nrel.gov/hydrogen/
Pacific Northwest National Laboratory	www.pnl.gov/
Permitting Hydrogen Facilities	www.hydrogen.energy.gov/permitting/index.cfm
Volpentest HAMMER Training & Ed Center	www.orp.doe.gov/?page=355&parent=326
U.S. Department of Transportation	
Bureau of Transportation and Statistics	www.bts.gov/
Federal Motor Carrier Safety Admin	www.fmcsa.dot.gov/facts-research/art-public-reports.asp
Hydrogen Portal	hydrogen.dot.gov/
Pipeline & Hazardous Materials Safety Admin	phmsa.dot.gov/hazmat
Other	
FuelCellStandards.com	www.fuelcellstandards.com/
Hydrogen and Fuel Cell Safety (USFCC)	www.hydrogenandfuelcellsafety.info/
Hydrogen Executive Leadership Panel (NASFM)	www.nasfmhydrogen.com/
National Fire Protection Association (NFPA)	www.nfpa.org
National Hydrogen Association (NHA)	www.hydrogenassociation.org/
U.S. Fuel Cell Council (USFCC)	www.usfcc.com/

These web-based resources have extensive information that can directly assist anyone addressing the topic of hydrogen safety. This is especially true for permitting officials and emergency first responders who may have applications in their jurisdiction. In addition,

manufacturers generally provide safety guides and procedures for their equipment and vehicles that contain or use hydrogen.

Of particular interest is the U.S. Department of Energy "Hydrogen Safety Bibliographic Database", which contains over 400 documents in a searchable database relating to hydrogen safety. Another example is a summary of over 200 codes and standards addressing the multitude of safety issues relating to hydrogen safety with fuel cells on the website "FuelCellStandards.com". This site is regularly updated and provides a range of helpful details such as the status of each document, a calendar of meetings, and a bulletin board for posting and answering questions.

Another initiative that is of interest to fire safety professionals is the "Hydrogen Education Leadership Panel" or "HELP", which is administered by the National Association of State Fire Marshals as another initiative supported through the U.S. Department of Energy.[42] Its purpose is to help achieve some consistency in permitting hydrogen refueling units at existing gas stations in the United States. The program has operated in two phases. Phase one began by applying existing model codes to a small number of representative refueling stations where hydrogen refueling units are being proposed, and presenting the results to state and local fire and building code officials. Phase two is focusing on a final document to inform code officials' education and training programs.

Current and Future Hydrogen Applications

Hydrogen is becoming increasing popular in today's world as a fuel source for vehicle propulsion and for power generation at fixed sites. The hazards associated with the handling of hydrogen as a fuel can be grouped into four basic categories. All applications, including hydrogen refueling stations and hydrogen back-up power installations, will utilize at least one of these categories. These are:[43]

1) hydrogen production;
2) hydrogen delivery;
3) hydrogen storage; and
4) hydrogen use.

Hydrogen Production

The production of hydrogen involves the manufacture of hydrogen fuel. Hydrogen can store and deliver usable energy, but it doesn't typically exist by itself in nature, and it must be produced from compounds that contain it. Thus it is not considered an energy source but instead an energy carrier.

The basic processes used to create hydrogen include: thermal, electrolytic, and photolytic. Thermal processing involves natural gas reforming, renewable liquid and bio-oil processing, and biomass and coal gasification. Electrolytic processing uses energy resources for water splitting. Photolytic processing also involves splitting water using sunlight through biological and

electrochemical materials. In some cases these processes may be centralized to create bulk hydrogen; otherwise they are used in a localized manner for creation of hydrogen on-site (i.e. at a distribution center, or application using hydrogen).[44]

For example, the process of using electrolysis to generate hydrogen (from water) is technologically straight-forward, allowing the realistic option of on-site hydrogen production for installations such as motor vehicle refueling stations. An intriguing extension of this is for residential occupancies, where consumers could privately refuel their hydrogen powered motor vehicle using their own dedicated on-site hydrogen production (e.g. within their garage).

Hydrogen Delivery

The delivery of hydrogen involves its movement from the location it is produced to the locations or stages of locations where it is stored, and then ultimately used. For example, hydrogen may be moved from a bulk manufacturing site to a highway refueling station or a fixed site such as a telecommunication facility emergency power supply. In addition to the transport mechanisms themselves, this infrastructure also includes the piping, equipment and facilities needed to load and unload the respective transport units.[45]

The delivery infrastructure includes ground fuel transport vehicles such as delivery trucks and railroad tank cars, maritime vessels such as barges and ships, and above ground and underground pipelines. Roadway vehicle and rail transport are the more common modes of bulk delivery, and the use of pipelines in relatively limited, especially when compared with other common fuels like natural gas that use extensive pipelines throughout the U.S. Table 1-5 summarizes the length of pipelines used for hydrogen delivery in the United States as of 2008.

Table 1-5: Summary of U.S. Hydrogen Pipeline by State [46]

STATE	LENGTH OF HYDROGEN PIPELINE, KM (MILES)
Texas	1363.9 (847.6)
Louisiana	466.7 (290.0)
Alabama	49.7 (30.9)
Indiana	24.1 (15.0)
California	20.8 (12.9)
West Virginia	10.8 (6.7)
Michigan	10.5 (6.5)
Ohio	2.9 (1.8)
New York	1.1 (0.7)
Delaware	1.0 (0.6)
Total	1951.5 (1212.7)

An advantage that hydrogen has over other conventional and alternative fuels is that technology is readily available to produce hydrogen on-site. Such an arrangement effectively eliminates the need for delivery. This minimizes the risks associated with delivery (e.g. bulk highway transportation), although it may introduce new hazards (e.g. on-site hydrogen production in residential occupancies) that today are not normally encountered by the emergency responders.

Hydrogen Storage

The storage of hydrogen can be accomplished through several approaches. Common methods include as a compressed gas or as a cryogenic liquid. Storage as a compressed gas requires high pressure tanks, designed for typical vessel pressures of 34.5 MPa (5,000 psia) to 69 MPa (10,000 psia). Cryogenic liquid storage requires cryogenic temperatures since the boiling point of hydrogen at one atmosphere pressure is -252.8°C (-423.0°F). Additionally, hydrogen can also be stored within solids in a process called absorption where hydrogen particles are sponged into another material. Similar storage is accomplished on the surfaces of solids by a process called adsorption, where hydrogen clings to the surface of another material like a thin sheet, either as hydrogen molecules or as hydrogen atoms.[47]

A hydrogen storage issue that is the focus of attention from equipment designers and engineers is the long term endurance of containment metals due to embrittlement. This occurs when the small hydrogen atoms seep in between the large metal molecules. The hydrogen then reforms into other molecules, expands, and pushes the metal molecules apart, similar to frost-heaves caused by freezing water in roadways. Over time embrittlement can create fissures in the metal of its container, increasing the risk of safety hazards. Many carbon steels and copper alloys are susceptible to hydrogen embrittlement, and the most stable containment systems for high pressure gaseous hydrogen are constructed with Type 316 or Type 316L steel alloys.[48]

Hydrogen Use

The use of hydrogen for transportation or power generation is primarily accomplished through fuel cell technology. Fuel cells can be found at fixed sites for power generation, or on roadway vehicles and other mobile applications such as industrial lift trucks (i.e. forklifts).

Fuel cell technology uses the chemical energy of hydrogen to produce electricity. There are several primary types of fuel cells, based on the type of "electrolyte" used. Each of these types has specific advantages and disadvantages, depending on the particular fuel cell application. These types include: Polymer Electrolyte Fuel Cells (PEFC); Proton Exchange Membrane Fuel Cells (PEMFC); Phosphoric Acid Fuel Cells (PAFC); Molten Carbonate Fuel Cells (MCFC); Solid Oxide Fuel Cells (SOFC); Alkaline Fuel Cells (AFC); Direct Methanol Fuel Cells (DMFC); Regenerative Fuel Cells; and Metal Air Fuel Cells.[49]

Fuel cells are unique in terms of the variety of their potential applications; they can provide energy for systems as large as a utility power station and as small as a laptop computer. Fuel cells have several benefits over conventional combustion-based technologies currently used in many power plants and passenger vehicles. They produce much smaller quantities of greenhouse gases and none of the air pollutants that create smog and cause health problems. If pure hydrogen is used as a fuel, fuel cells emit only heat and water as byproducts.[50]

Vehicles fueled by emerging fuels are increasing in number due to economic and regulatory pressures. In addition to hydrogen, other alternative fuels include: methanol, ethanol and other alcohols; blends of alcohol with gasoline; natural gas and liquid fuels domestically

produced from natural gas; liquefied petroleum gas (propane); coal-derived liquid fuels; electricity; bio-diesel; and P-series fuel.[51] For the period between 1994 and 2003, over sixty passenger vehicle models fueled by hydrogen were produced, ranging from compacts to minivans to SUV's. Many of these vehicles were experimental or concept vehicles while some were production prototypes.[52]

Hydrogen fuel cell vehicles have an electric drive-train powered by a fuel cell that electrochemically generates power from hydrogen. At present, the most common method of storing and delivering hydrogen fuel onboard is in compressed gas form. Hydrogen must be compressed to high temperatures or liquefied at cryogenic temperatures in order to fit enough fuel onboard vehicles to achieve typical driving ranges.[53]

Today, because hydrogen is not widely found in mainstream applications, its use and possible hazard characteristics are not of a high-focused concern among fire safety professionals as compared to other more commonly available hazardous materials. However, this is changing as certain technological innovations are enabling the proliferation of hydrogen use beyond its more traditional industrial uses. As time progresses, fire safety professionals can expect a greater likelihood of encountering more mainstream applications (vehicles, refueling sites, fixed power generation, etc) using hydrogen.

Focus Applications

This study addresses applications using hydrogen and seeks to improve the transfer of hydrogen safety information to and from the fire service. While there are numerous different applications involving hydrogen, the following two applications in particular are the subject of specific focus:

1) Hydrogen refueling stations; and
2) Hydrogen back-up power installations (e.g. for telecommunications facilities).

Although these two focus applications may not be commonplace at this time in many jurisdictions, it is not unusual for a particular community to be familiar with hydrogen since it is not uncommon for it to be used in industrial processes and other specialized uses. The 1978 report generated by Factory Mutual Research Corporation addressing losses from 1965 through 1977 illustrates this point.[54] These industrial and specialized applications could appear in any jurisdiction and, for example, include: ammonia synthesis, oil refining, methanol synthesis, hydrogenation of fats/oils, production of metal ores, rocket propellant, electric motor cooling, electronics processing, and miscellaneous chemical processes.

Hydrogen refueling stations

Detailed information on these two applications is available from the U.S. Department of Energy "hydrogen.energy.gov" website, and this information is summarized herein for convenience (see www.hydrogen.energy.gov/permitting/index.cfm).[55] Of these two focus applications, hydrogen refueling stations have similarities with other hazardous materials applications

familiar to permitting officials (e.g. refueling stations for gasoline, CNG, etc), while hydrogen back-up power installations for telecommunications and similar facilities are a less obvious and less familiar application.

The first focus application involves a prototypical hydrogen refueling station. Figure 1-6 illustrates a prototypical service station application providing hydrogen. While such a facility could be stand-alone and only handle hydrogen, it is more likely to be configured to also dispense a variety of other fuels such as gasoline or CNG. In addition to issues normally addressed by permitting officials such as built-in fire protection measures and site issues (set-backs, zoning, etc), variables of prime concern generally include the state/condition in which hydrogen will be provided (gaseous or liquid), storage capacity, storage methods (e.g. aboveground versus underground), bulk delivery, and methods of dispensing. The typical safety features are summarized in Table 1-6, and the pertinent details for a typical prototype refueling facility are provided in Table 1-7.

The primary safety concerns within the hydrogen fueling and fuel storage subsystem are the compressed-hydrogen fuel containers, which include safety components such as pressure relief devices and container shut-off valves. These fuel containers are specially designed to allow the storage of hydrogen at very high pressures.

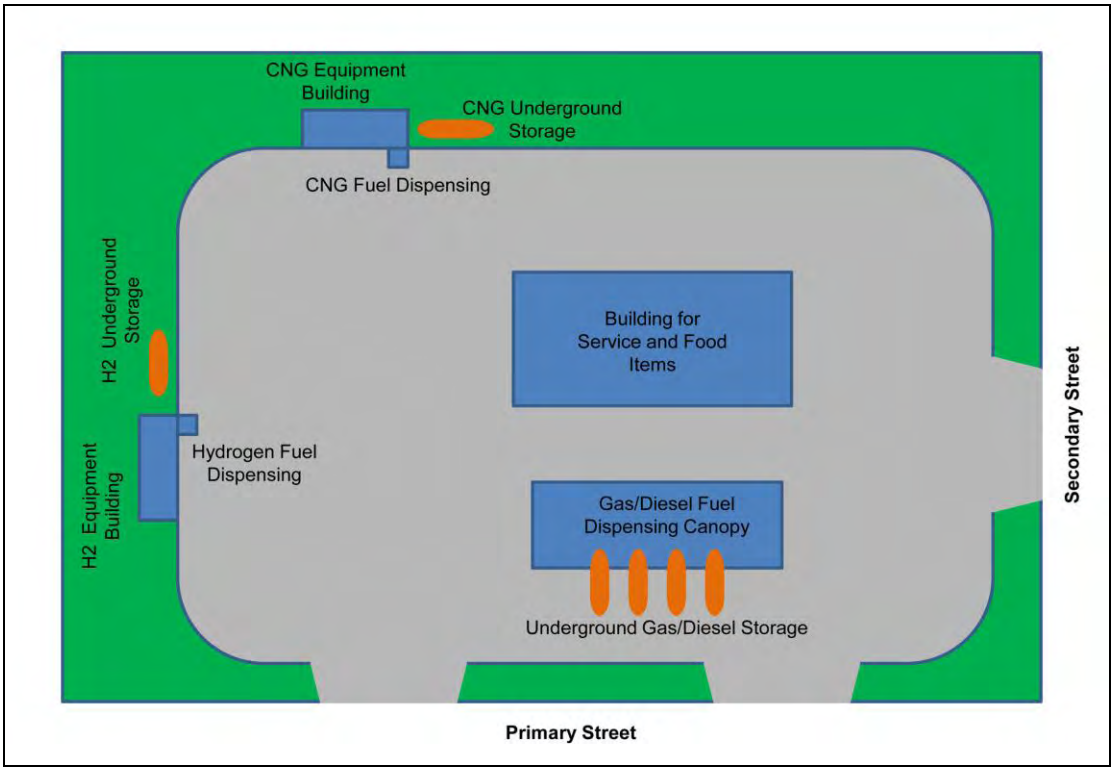

Figure 1-6: Typical Service Station Site Layout

Compressed gas bulk storage of hydrogen has similar storage characteristics with smaller storage systems, such as those used in vehicles. Current developmental vehicles typically store

hydrogen at 34.5 MPa (5,000 psia), and some prototype vehicles are in development with storage vessels that will operate up to 69 MPa (10,000 psia). The hydrogen fuel from the storage containers is supplied to the fuel cell by pressure piping with two or three stages of regulation that reduce the pressure to approximately 0.034 MPa (5 psi) before entering the fuel cell stack.[57]

Table 1-6: Typical Safety Features for a Prototypical Refueling Facility [56]

SAFETY FEATURES	TECHNICAL DETAIL
Station	Emergency shut-offs; Hydrogen detectors; and Flame detectors
Hydrogen Storage	Tank vent active control valves for vapor control; and Pressure relief devices
Dispensing	Vapor control at the dispenser by means of vapor capture; Breakaway hoses; Below-grade piping; Electrical grounding; Crash bars around dispensers

In addition, these facilities will be a collection point for hydrogen powered vehicles, and at any given time the facility can be expected to include multiple vehicles on the property which introduces an additional hazard. The key safety hazards of compressed-hydrogen fuel cell vehicles include: combustion hazards; crash hazards; electrical hazards; fire hazards; and high pressure hazards.[58]

Table 1-7: Technical Details for a Prototypical Refueling Facility [59]

TOPIC	TECHNICAL DETAIL
Fuels Available:	(1) Gasoline; (2) Gaseous hydrogen at 34.5 MPa (5,000 psia); (3) Gaseous hydrogen at 69 MPa (10,000 psia); and (4) Liquid hydrogen.
Hydrogen Delivery:	Liquid hydrogen is delivered to the station by a tanker truck.
Liquid Hydrogen Storage:	The liquid hydrogen is stored below-grade in 5,700 L (1,500 gal) double-walled, insulated, stainless-steel vessels at -251 °C (-420°F).
Vaporizer:	A vaporizer vaporizes the liquid hydrogen by raising its temperature from -251 °C (-420°F) to ambient temperature.
Compressors:	A three-stage compressor compresses the vaporized gas to 38 MPA (5,500 psia). A one-stage compressor compresses it to 76 MPa (11,000 psia).
Gaseous Hydrogen Storage:	Gaseous hydrogen from the compressor is stored at 38 MPA (5,500 psia) in 24 ASME cylinders (above grade) and at 76 MPa (11,000 psia) in 3 ASME cylinders (above grade).
Dispensers:	One liquid hydrogen dispenser and one gaseous hydrogen dispenser with dual hoses for dispensing at 34.5 MPa (5,000 psia) and 69 MPa (10,000 psia), at 20 kg (44 lbs) per day.

<u>Hydrogen back-up power installations (e.g. for telecommunications facilities)</u>

The second focus application involves a hydrogen back-up power installation for a prototypical facility such as those used for telecommunications. This application exemplifies any fixed site using emergency back-up power generation. Key differences from a refueling station are the lack of dispensing equipment; much lower storage quantities; limited access by the public; and various other details. Figure 1-7 illustrates a typical site layout for a stationary fuel cell installation.

From a permitting standpoint, there are five key safety issues for stationary fuel cell applications:[60]

1) fuel supply and storage outside the fuel cell;
2) general fuel cell siting for outdoor and indoor installations;
3) fuel cell equipment;
4) fire protection; and
5) interconnections.

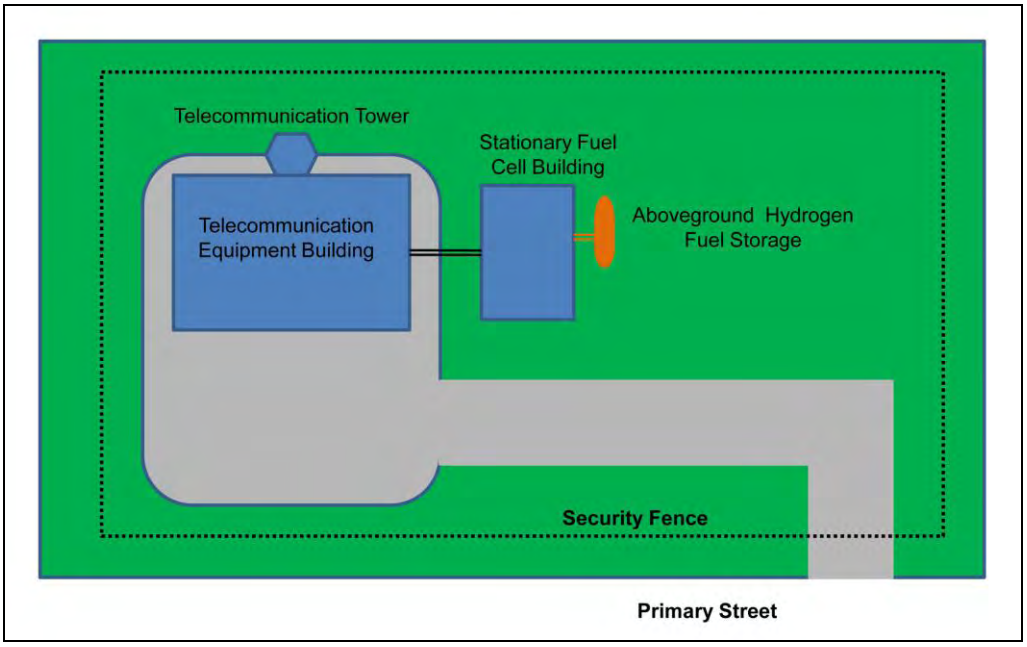

Figure 1-7: Typical Stationary Fuel Cell Fixed Site Layout for Telecommunications

There are multiple technological approaches that are used for the design of fixed site fuel cells; from these have evolved four basic types used in stationary installations for commercial applications. Fuel cells are classified primarily by the kind of electrolyte they employ, and the four basic types are: molten carbonate fuel cells (MCFCs); phosphoric acid fuel cell (PAFCs); proton exchange membrane fuel cell (PEMFCs); and solid oxide fuel cells (SOFCs).

In recent years there has been significant proliferation of cell phone towers and other telecommunications facilities. To maintain reliable service and prevent outages, most facilities include some level of backup power to remain operational at all times. Fuel cell technology offers certain advantages over other methods and is becoming the emergency power supply of choice for industries like telecommunications. [61] Although initial costs are typically more than for power supplies using conventional fuels, long term cost savings can offset initial costs based on advantages that include:

- Longer, definable run time;
- Improved ability to remotely monitor;
- Longer service life;
- Less maintenance (no moving parts);
- Wider operating temperature range, i.e. –40°C to 50°C (–40°F to 122°F);
- Compact footprints;

- Environmentally and acoustically friendly; and
- Effective operating efficiencies.

Fixed site fuel cell applications can vary significantly in size, and can be as large as one megawatt or more of power generation capacity. For example, recently a 1.2 megawatt fuel cell power plant came on-line in Bloomfield CT for a 24,000 square meter (260,000 square foot) industrial bakery. Another noteworthy application is a set of twelve fuel cells that will provide 4.8 megawatts of power for the new Freedom Tower and related towers at the World Trade Tower site in lower Manhattan.62 Interestingly, facilities supporting the activities of emergency responders are strong candidates for fixed site hydrogen fuel cell technology, since they, like the telecommunications industry, depend on emergency power supplies for their critical infrastructure, i.e., communications networks, fire stations, health care, etc.[63] Figure 1-8 illustrates typical hydrogen fuel cells used for emergency power generation, and located in an exterior setting.

Figure 1-8: Example of Stationary Fuel Cells for Power Generation

Stationary fuel cell power supplies, whether for telecommunications or other uses, present greater challenges to safety officials when located in close proximity to other structures and occupancies. For example, permitting officials will likely be less concerned with remotely located telecommunications towers than for fuel cell installations used for occupancies with greater risk exposures, such as for hospitals with immovable occupants or casinos that include large assembly occupancies.

Both of these examples (i.e. hospitals and casinos) regularly utilize emergency backup power systems, and hydrogen fuel cells are an attractive alternative to conventional approaches for reasons such as minimal environmental impact, cleanliness, low noise, etc. In such cases, efforts to minimize storage of hazardous fuel supplies can alleviate safety concerns, and can be accomplished through approaches such as using already available piped natural gas that is reformed on-site into hydrogen and then immediately used in the fuel cell, thus mitigating storage concerns.

3) Fire Service and Related Organizations

In the United States and in many other countries the fire service does not exist as a single homogeneous organization, or one that can be reached through a single advocacy organization. One of the underlying purposes of this report is to provide an understanding of the safety infrastructure within the United States and the role of the fire service therein.

This section provides general information to better understand the U.S. fire service and related organizations associated with it. Specifically, it provides a primer on the structure of the fire service in the United States, with details on jurisdictional boundaries, organizational types, typical responsibilities, and key organizations.

This information is intended to have a specific focus on both the permitting officials' infrastructure and the emergency first responders' infrastructure. The focus on the permitting officials' infrastructure will clarify the overall infrastructure of the authorities having jurisdiction (AHJs) in the United States, including AHJs that operate by legislative mandate (e.g. fire inspectors, building officials) and those that do not (e.g., insurance industry). The focus on the emergency first responders' infrastructure clarifies fire service member organizations and proven effective education and communication methods that they use.

Emergency First Responders

The safety infrastructure comprises all activities that keep us safe from harm. To some extent, safety is proactively designed into almost all products, and can range from passive design characteristics such as the type of materials used in consumer goods (e.g. toys), to active safety features such as automatic sprinkler systems in buildings.

These passive and active safety characteristics and features are intended to mitigate hazards to prevent them from occurring or keep them from escalating. In contrast, other parts of our safety infrastructure provide reactive manual intervention to address these hazards once they are beyond the protection capabilities of built-in passive and active safety measures.

Virtually anywhere in the United States a person can pick-up the telephone to report an emergency and can expect someone to respond, even in extremely remote wilderness areas where response will take a significant amount of time. The professionals who respond to these emergencies are "emergency first responders", also referred to as "first responders".

Emergency first responders are defined as "a group designated by a community as those who will first respond to an incident", and are usually composed of local police, emergency medical service providers, and the fire service.[64] These personnel are engaged as the front-line

resources responding to any given emergency. They are further defined in NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents* as follows:

> *"Emergency First Responder Personnel. Those persons, including members of fire departments, police departments, other law enforcement agencies, hazardous materials response teams, emergency medical services, and other organizations that have public safety responsibilities and who would respond to rescue and treat victims, and who would protect the public during an emergency incident."*[65]

Clarification of this definition is found in the "Emergency Response Guidebook", which is a key reference publication used by emergency first responders for hazardous materials throughout North America.[66] This Guidebook is expressly intended for first responders, and it indicates that it is "for use by firefighters, police, and other emergency services personnel" who may be the first to arrive at the scene of a transportation incident involving a hazardous material. The document is published and provided free of charge by the U.S. Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico, and its circulation is very widespread. To date it is estimated that nearly eleven million copies have been distributed without charge to the emergency response community.[67]

Emergency first responders are an important part of our safety infrastructure. They generally operate by responding to initiate action, control and mitigation of a particular hazard or problem. Emergency first response organizations are arguably reactionary in overall composition, based on a high percentage of staffing and equipment devoted to response operations like fire suppression and rescue.[68] However, certain key line functions are proactive such as fire and crime programs that involve inspection, prevention, education, and fire & life safety campaigns supporting these programs.

From an overall context the fire service is one of three key groups in the spectrum of emergency first responders, along with emergency medical services and law enforcement. Figure 1-9 summarizes these three groups within the framework of the safety infrastructure.

Several other occupational groups are also directly involved with the safety infrastructure, although they don't normally respond to the scene of an event (except within their own facilities) and thus are one step removed as "first responders". For example, hospital, clinical & medical personnel are the ultimate recipients of emergency victims. Although they are not "responding" directly to the scene of an emergency incident, they are nevertheless a critical part of the emergency response chain.

Federal regulations (29 CFR 1910.120(q)) administered by the U.S. Occupational Health and Safety Administration (OSHA) recognize healthcare workers and hospital employees receiving victims as "first receivers". Meanwhile, the "first responders" are the fire fighters, police officers and emergency medical technicians responding to an emergency.[69]

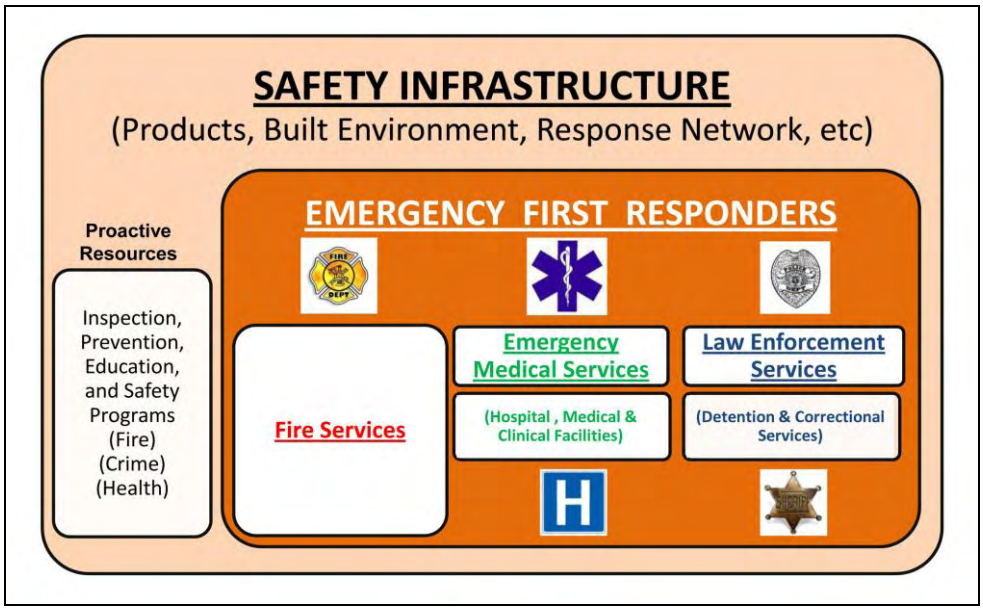

Figure 1-9: Overall Safety Infrastructure with Emergency Response Personnel.

Yet another constituent group that is arguably similar to hospital, clinical & medical personnel "receivers", and indirectly associated with the emergency response chain, is detention and correctional facility personnel. For example, in the National Occupational Research Agenda for emergency service personnel administered by National Institute for Occupational Safety and Health (NIOSH) they are viewed equally as having certain similar occupational hazards as law enforcement, emergency medical service and fire service.[70] However, their response is limited to emergencies within the facilities they are assigned to protect.

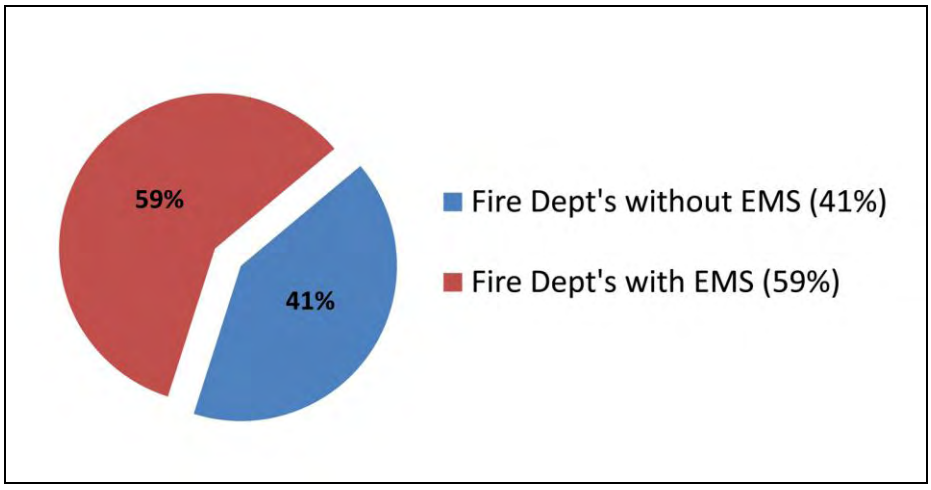

Figure 1-10: Combined Fire Services and Emergency Medical Services (EMS) [73]

In many jurisdictions these response services operate as distinctly separate organizational entities; in some they are combined. Most common is the combination of fire service resources with those of involving emergency medical services. Based on data collected for the period between 2005 and 2007, 59 percent of the fire departments in the United States also provide

emergency medical services. This is shown in Figure 1-10, which illustrates the percent of departments that have combined fire services and emergency medical services.[71]

Occasionally, fire-rescue services are combined with police and other law enforcement services in a public safety department. While this model is not unusual in other countries, it is relatively uncommon within the United States. Since all departments in a municipal government ultimately report to a single individual or entity, such as a mayor, city council, or town council, the difference between separate fire-rescue and police departments versus a public safety department effectively translates to where in the reporting chain the top leadership or "chief of department" resides.[72]

Fire Service Personnel

How do we define a fire fighter? To the lay-person, describing a fire fighter and the other related organizations that comprise our safety infrastructure may initially seem relatively straight-forward. However, upon further detailed review, the complexities of this question quickly become apparent. The famous quote from U.S. Supreme Court Justice Potter Stewart applies here that: "I know it when I see it", as a figure of speech sometimes used to describe something readily obvious on the surface but difficult to define.[74]

A minor grammar technicality that is somewhat symbolic of the difficulties of defining a fire fighter is the interchangeable use of the terms "fire fighter" (i.e. two words) and "firefighter" (i.e. single word) in the mainstream literature. In this report, the term "fire fighter" will be used, unless it is part of an official title or name. This recognizes that the descriptive two-word term "fire fighter" is used in the title of the IAFF: International Association of Fire Fighters, one of the key professional groups in today's fire service.

Some of the definitions of fire fighter found in the common literature include the following:

> *"Fire Fighter: An individual qualified by training and examination to perform activities for the control and suppression of unwanted fires and related events"*[75]
>
> *"Fire Fighter: An active, participating member of a fire department, including volunteers and part-time firemen"*[76]
>
> *"Fire Fighter: An active member of a fire department, paid or volunteer"*[77]

More precisely, the term fire fighter (career or volunteer) is defined throughout the NFPA Professional Qualification standards, which set the minimum job performance requirements for the fire service. NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, defines two distinct types of fire fighters for structural firefighting as follows:[78]

Fire Fighter I: The person, at the first level of progression (as defined in Chapter 5 on Fire Fighter I), who has demonstrated the knowledge and skills to function as an integral member of a fire-fighting team under direct supervision in hazardous conditions.

Fire Fighter II: The person, at the second level of progression (as defined in Chapter 6 on Fire Fighter II), who has demonstrated the skills and depth of knowledge to function under general supervision.

The NFPA Professional Qualification standards provide an important baseline of understanding of the necessary qualifications for a fire fighter. Further, a series of sixteen detailed NFPA standards address not only structural fire fighting, but also other specialized fire fighter job functions and disciplines, such as fire officer, fire inspector, and fire investigator.

The entire series of professional qualification standards are summarized in Figure 1-11, and provide an indication of the types of qualified fire fighters that exist today. This also provides an outline of the primary recognized tasks performed by fire fighters, which typically require special operational skills, training, and other job oriented features.

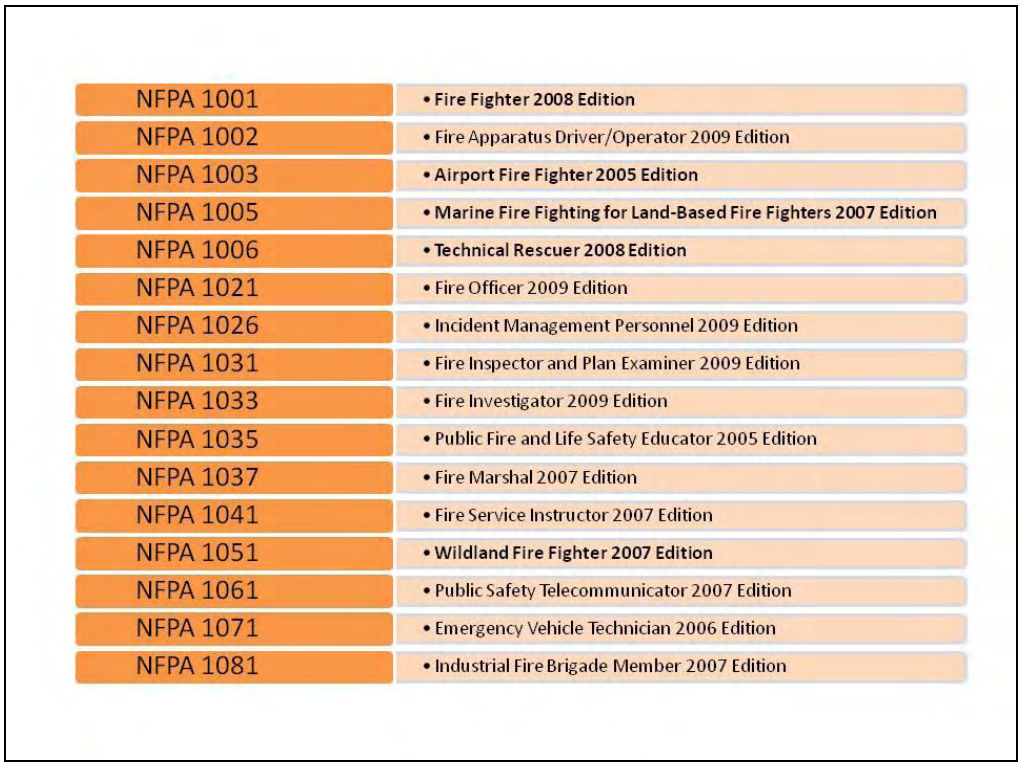

Figure 1-11: Types of Fire Fighters, according to NFPA Professional Qualification Standards.

These detailed standards describe the qualifications necessary to perform the respective duties of various types of fire fighters. However, as with any occupation or profession, additional definitions are used to address other important matters such as contractual employment

obligations, statistical tabulation and benefit distributions. [79] For example, the Fair Labor Standards Act of 1938, along with further clarification from Public Law 106-151 (passed by U.S. Congress in December 1999), defines for compensation purposes "employees engaged in fire protection activities".[80] Specifically, an employee in fire protection activities' is: [81]

> *…an employee, including a firefighter, paramedic, emergency medical technician, rescue worker, ambulance personnel, or hazardous materials worker, who:*
>
> 1) *is trained in fire suppression, has the legal authority and responsibility to engage in fire suppression, and is employed by a fire department of a municipality, county, fire district, or State; and*
> 2) *is engaged in the prevention, control, and extinguishment of fires or response to emergency medical situations where life, property, or the environment is at risk.*

Table 1-8: Number of Fire Fighters by Population Size [83]

Population Protected	Career Fire Fighters	Volunteer Fire Fighters	Total Fire Fighters
1,000,000 or more	38,350	400	38,750
500,000 to 999,999	31,800	7,200	39,000
250,000 to 499,999	23,400	3,250	26,650
100,000 to 249,999	50,700	1,950	52,650
50,000 to 99,999	46,600	6,900	53,500
25,000 to 49,999	48,650	24,400	73,050
10,000 to 24,999	50,450	84,250	134,700
5,000 to 9,999	15,700	109,400	125,100
2,500 to 4,999	8,000	162,050	170,050
Under 2,500	9,700	425,650	435,350
Total	323,350	825,450	1,148,800

In the United States there are an estimated 1.1 million fire fighters, with approximately three-fourths of these fire fighters serving as volunteers.[82] Table 1-8 provides a summary of the career and volunteer fire fighters in the United States as of 2007, based on the size of the jurisdiction protected.

As expected, the more populated jurisdictions are protected primarily by career fire fighters while rural areas are protected primarily by volunteer fire fighters. The total of 1,148,800 career and volunteer U.S. fire fighters indicated in Table 1-8 is an estimate based on a sample survey with a confidence level associated with each estimate, and does not include certain fire fighter constituency groups such as industrial fire departments and federal fire departments.

Fire Service Organizations

To be effective, a fire fighter operates as part of a bigger unit, team or entity generally known as a "Fire Department", this being the basic organized group constituting fire service

organizations. These are synonymously referred to as fire brigades (e.g., for certain applications, like industrial), and likewise, in various parts of the world other than North America (e.g. Europe) they are more commonly referred to as "Fire Brigades".

Generally speaking, a fire department can be assumed to be an organization composed primarily of fire fighters. A useful definition is that which is used in NFPA codes and standards as "an organization providing rescue, fire suppression, and related services."[84] Some other definitions of "Fire Department" found in the common literature are:

> *"Fire Department: An organization providing rescue, fire suppression, and related activities, including any public, governmental, private, industrial, or military organization engaging in this type of activity."*[85]
>
> *"Fire Department: A professional organization, usually provided by a government but may be a private concern, for the prevention or extinguishment of fires."*[86]
>
> *"Fire Department: A public or private fire-fighting organization that provides fire prevention, extinguishment, and sometimes emergency rescue service to a community, municipality, fire district, or other political subdivision, consisting of one or more companies headed by a chief of department."*[87]
>
> *"Fire Department: A public fire protection organization, usually a department of municipal or county government that provides fire prevention, fire extinguishment, and emergency rescue service to a given jurisdiction."*[88]

In the United States, fire service organizations most commonly operate as an entity within the framework of local government. Generally, they are a distinctly separate department within the local county, city or town government, side by side with the police and other municipal departments.

Table 1-9: Number of Fire Departments in the U.S. by Population Protected [90]

Population Protected	Total Number of fire Departments
1,000,000 or more	15
500,000 to 999,999	37
250,000 to 499,999	64
100,000 to 249,999	244
50,000 to 99,999	513
25,000 to 49,999	1,277
10,000 to 24,999	3,555
5,000 to 9,999	4,386
2,500 to 4,999	5,770
Under 2,500	14,324
Total	30,185

As shown in Table 1-9, in 2007 there were an estimated 30,185 fire departments in the United States.[89] Complicating data collection, 3,019 of these 30,185 fire departments are affiliated with each other and share certain administrative duties such as fire records, and thus an effort is made to prevent double counting.

Table 1-10: Type of Fire Department in the U.S. by Population Protected [91]

	Types of Fire Departments				
Population Protected	All Career (%)	Mostly Career (%)	Mostly Volunteer (%)	All Volunteer (%)	Total
1,000,000 or more	75.0	25.0	0.0	0.0	100.0 %
500,000 to 999,999	71.0	16.1	12.9	0.0	100.0 %
250,000 to 499,999	64.5	29.0	6.5	0.0	100.0 %
100,000 to 249,999	86.3	12.0	1.7	0.0	100.0 %
50,000 to 99,999	69.2	22.8	6.2	1.8	100.0 %
25,000 to 49,999	41.2	28.2	22.5	8.0	100.0 %
10,000 to 24,999	20.8	18.8	42.3	18.1	100.0 %
5,000 to 9,999	4.9	5.2	36.1	53.8	100.0 %
2,500 to 4,999	0.5	3.0	18.8	77.7	100.0 %
Under 2,500	0.8	1.1	3.4	94.7	100.0 %
Total	7.5	5.8	16.5	70.1	100.0 %

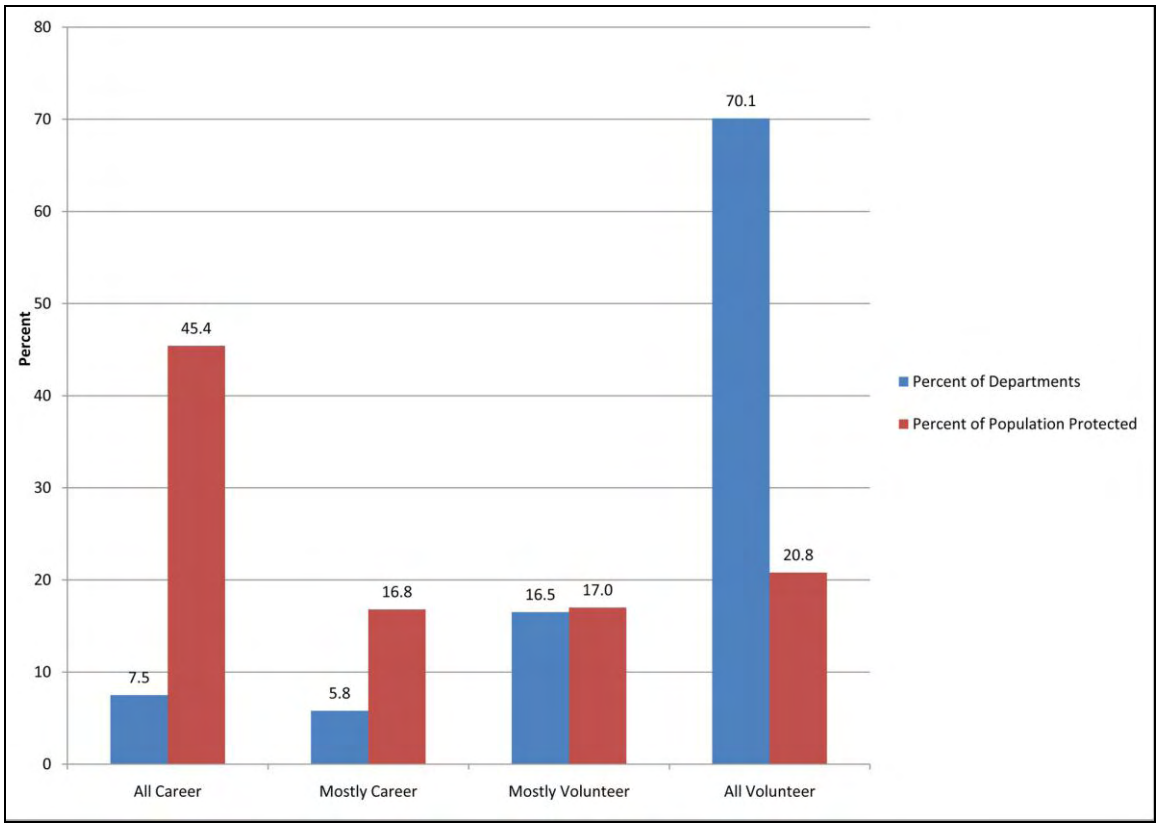

Figure 1-12: Percent of Fire Departments and U.S. Population Protected by Department Type [92]

The percentage of fire departments by type is shown in Table 1-10. This is separated into four basic sub-divisions for type of fire department as follows: all career comprised of 100 percent

career fire fighters, all volunteer comprised of 100 percent volunteer fire fighters, mostly career comprised of 51 percent to 99 percent career fire fighters, and mostly volunteer comprised of 1 percent to 50 percent career fire fighters.

The data in Tables 1-10 and 1-11 is illustrated graphically in Figure 1-12. The populations protected by the types of departments are quite different, since high density population areas are normally protected by career or mostly career fire departments.

In most cases, the approximate 30,000 fire departments closely parallel the local town or city government. Putting this into context requires considering the normal governmental reporting structure in the United States. First, the 50 individual states are normally comprised of multiple counties (with several to several hundred), and these in turn are further comprised of dozens to hundreds of incorporated cities and town. These cities and towns are also referred to as "municipalities", which are generally considered to be a corporation representing a defined geographic area established by the state legislature for the good of the inhabitants.[93] This is visually illustrated in Figure 1-13. Some states also include unincorporated districts administered by the county or states.

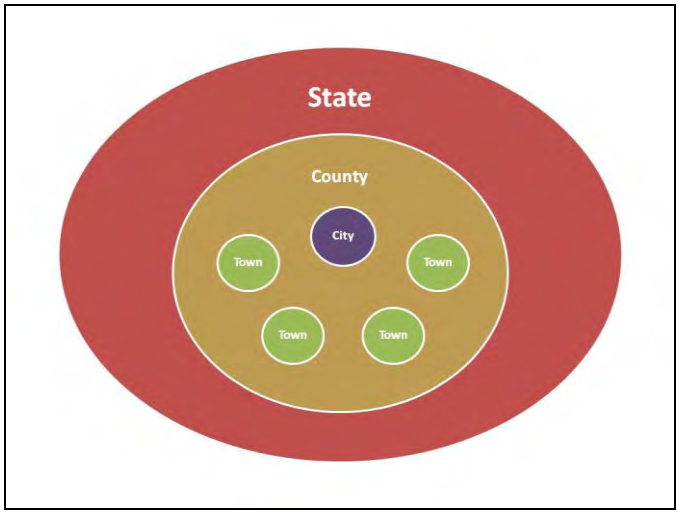

Figure 1-13: Hierarchy of State, County and Local Government

In some jurisdictions, fire departments are designed to serve at the county government level rather than the local communities. For example, fire departments in the state of Maryland and Commonwealth of Virginia closely parallel the county governments.

Another approach are regional fire departments that represent an amalgamation of multiple local communities that likewise doesn't match the county government, such as in Colorado which has regional fire protection districts that don't necessarily match either the local towns/cities or counties. Some towns have fire departments that are tax districts within the towns boundaries that do not answer to the local government but instead to a separate board of fire commissioners (with empowerment to tax citizens in the district to recover costs).

Of the approximate 30,000 fire departments in the United States in 2006, the majority of these are municipal fire departments operating under the administration of the local town or city government, and these are the intended target populations for the survey. This is visually represented in Figure 1-14, which is the first in a series of five illustrations clarifying organizations that administratively host U.S. fire service activities.

Figure 1-14: U.S. Fire Service Administrative Hosting Organizations, Concept Step 1.

In some cases these local fire departments are county oriented rather than town or city, and for sake of this discussion they are considered a direct extension of the local government model. A variation of this is the region-based fire department model. These are the regional fire districts that exist in certain states such as in Colorado, and are different from county fire departments since they do not follow any pre-designated government boundaries (i.e. local town or county). Instead they protect a collection of multiple towns or districts that are generally independent of the county government.

Municipal fire departments in this model operate as a city government department like any other municipal department, and the employees are town or city employees for the community. One interesting modification of this approach is the use of contracted services to fulfill the duties otherwise handled by the municipal fire department. This is illustrated in Figure 1-15, which shows the second of a series of five illustrations representing organizations that administratively host U.S. fire service activities.

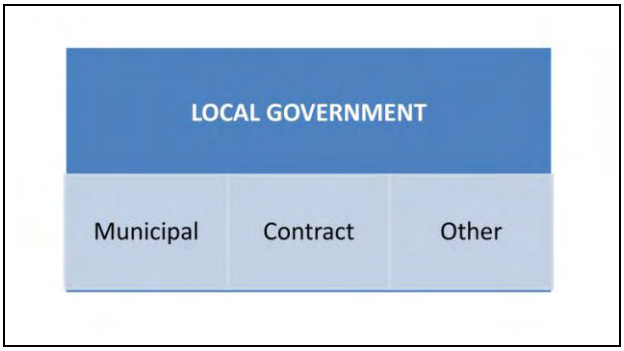

Figure 1-15: U.S. Fire Service Administrative Hosting Organizations, Concept Step 2.

One example of this type of contract service is the emergency services provided in Scottsdale, Arizona.[94] The citizens in this and other similar communities generally find no difference in their services whether it is a directly funded local government department, or a contracted service fulfilling the same role.

In addition to fire departments provided through the local governments, there are also fire departments funded and administered on a regional, state, or federal level. This is illustrated in Figure 1-16, which illustrates the third in a series of five illustrations on hosting organizations for the U.S. fire service.

The regional and state level includes organizations that extend beyond the local government municipalities. One example of these type of regional or state level departments is CalFire (California Department of Forestry and Fire Protection), which covers wildfire protection for the State of California.[95] Another example of a port authority is MassPort (Massachusetts Port Authority) which provides fire department coverage for the Boston harbor port, Logan International Airport, and other nearby assets such as major bridges and smaller local airports.[96] Some regional and state fire departments, such as these examples, have appreciable resources in terms of staff and equipment.

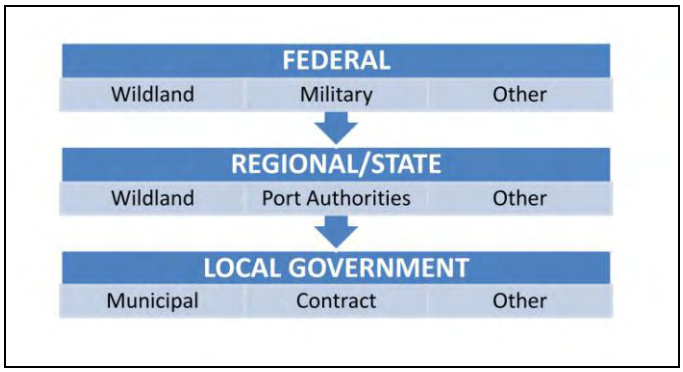

Figure 1-16: U.S. Fire Service Administrative Hosting Organizations, Concept Step 3

Another layer of government-based fire departments beyond local, regional and state are the fire departments that are administered by the federal government. This includes any large federal government installation requiring fire department protection. Examples include military installations, large national laboratories, and military hospital complexes. A specific example is the Montgomery County Fire Department, which as of 2009 utilizes 34 fire stations throughout the county, but also has an additional 5 federally operated fire stations within their jurisdiction for the National Naval Medical Center, National Institute of Health, Naval Surface Warfare Center, National Institute of Standards & Technologies, and Walter Reed Army Medical Center.[97]

Federal oriented fire departments often have special hazards that may require special training (e.g. handling military ordinances), and in addition, many of them are also installations which have restricted access or special security concerns. Further, certain fire protection applications

require significant coordination between states and local jurisdictions. For example, wildland fire applications often require this type of coordination, and this is addressed on the federal level through the U.S. Forestry Service.[98]

The most common model for organizations hosting U.S. fire departments is through local, regional/state, or federal based. However, other approaches exist that are independent of U.S. government support. This includes government authorities within the geographic boundaries of the United States but yet involve other government oversight. Figure 1-17 illustrates the fourth in the series of 5 illustrations that demonstrate how hosting organizations provide administration for the U.S. fire service.

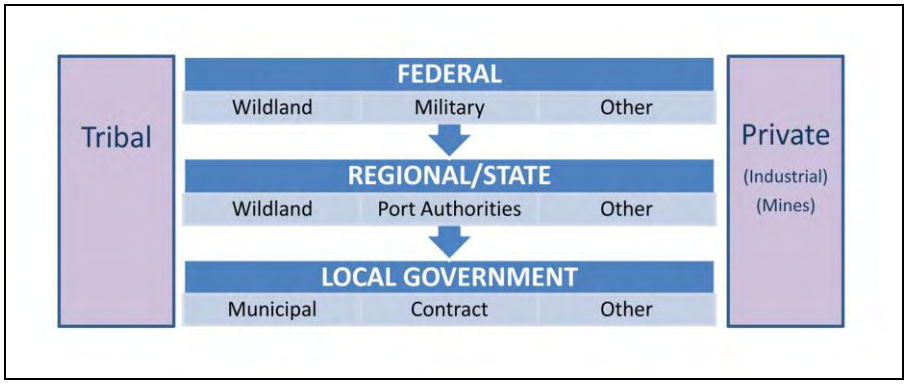

Figure 1-17: U.S. Fire Service Administrative Hosting Organizations, Concept Step 4

Most notably in this regard are the tribal authorities for Native American nations. In similar fashion are the fire departments and fire brigades that are privately funded and administered, such as with large industrial complexes. While most industrial plants have at least some type of industrial fire brigades (e.g. an electric generating plant), in some cases an industrial complex is significantly large such that it will have one or several fire stations equipped with staff and apparatus similar to the local municipal fire department. Further, some of these fire departments are highly specialized, depending on the particular industrial application. An example are the mine rescue teams that are the primary emergency first responders in an underground mine.

The most common fire protection applications in the built environment are structural buildings, and consequently, structural fire fighting is the most common type of fire fighting application. Structural fire fighters also address non-structural applications on a regular basis, such as fires and rescue activities involving motor vehicles. This is an assumed for Figures 1-14 through 1-17. In some cases, fire fighters are specially trained to address certain unique hazards, and these specialized or additional tasks are illustrated in Figure 1-18 (the fifth in a series of 5 illustrations that exemplify U.S. fire service administrative hosting organizations.

As indicated in Figure 1-18, examples of specialized fire fighting disciplines are aircraft rescue and fire fighting (ARFF), shipboard fire fighting for land based fire fighters, wildland fire fighting, and technical rescue operations. These can be special units within a fire department, or can be

stand alone fire and rescue operations. Each of these involves unique characteristics to the extent that an entire fire department or rescue operation may be entirely devoted to this specialty operation.

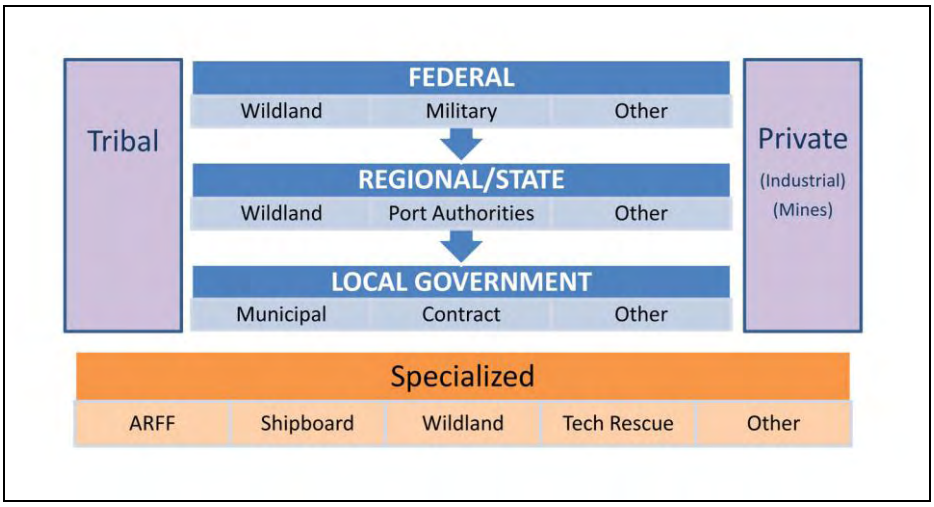

Figure 1-18: U.S. Fire Service Administrative Hosting Organizations, Concept Step 5

For example, this is commonly the case for ARFF crews that fulfill international and domestic protection required for all major international airports. These resources are designed to provide dedicated and rapid response to an aircraft fire or rescue incident. Another example are the specialized teams that handle technical rescue, for situations such as structural collapse, trench rescue, high altitude rescue, or water rescue.

A specific example would be the Mountain Rescue Service in the White Mountains of New Hampshire, with specialized technical skills for all-season high altitude mountain rescue as well as certain other applications like water rescue. They are one of several specialized volunteer rescue teams that function as emergency first responders to directly assist the New Hampshire Fish and Game Department with all-season wilderness rescue operations.[99]

A fire department requires staff to function. This staff can be individuals who volunteer their time such as volunteer fire fighters, paid-on-call fire fighters which are volunteers who get paid when they respond, or full-time employees, i.e. career fire fighters. Some fire departments are all volunteer, some are all career, and some are a combination of volunteer and career.

This is illustrated in Figure 1-19, which shows the three basic types of fire service organizations in the United States. This includes the percent of fire departments and the U.S. population protected by department type, which was described previously in Figure 1-12. A volunteer fire department has volunteer emergency service personnel comprising 85 percent or greater of its department membership, while a combination fire department is a fire department having emergency service personnel comprising less than 85 percent majority of either volunteer or career membership, and this leaves a career fire department as other than volunteer or combination department.[100]

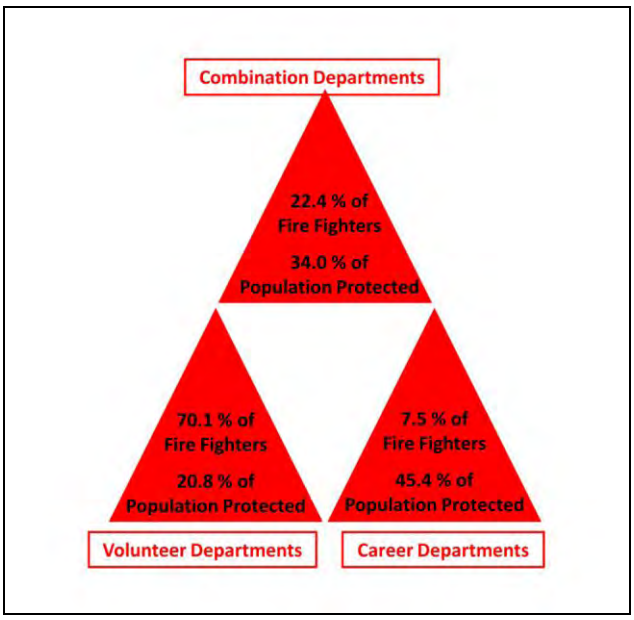

Figure 1-19: Basic Types of Fire Service Organizations in the United States

The duties performed by fire fighters include the operational activities that directly support their primary fire fighting and rescue mission, and their other supporting tasks, such as training, education, prevention, investigation, and administration. The operational duties are illustrated in Figure 1-20, and show the major types of operational functions performed by the U.S. fire service. This includes structural fire fighting, and non-structural fire fighting tasks like extrication at a motor vehicle accident. Emergency medical services (EMS) are often handled directly by the local fire department and are a significant component of the first emergency response spectrum. In addition, situation involving technical rescue, hazardous materials, and wildland fires affect many, and in some cases virtually all fire departments, and these are likewise considered key operational functions performed by the U.S. fire service.

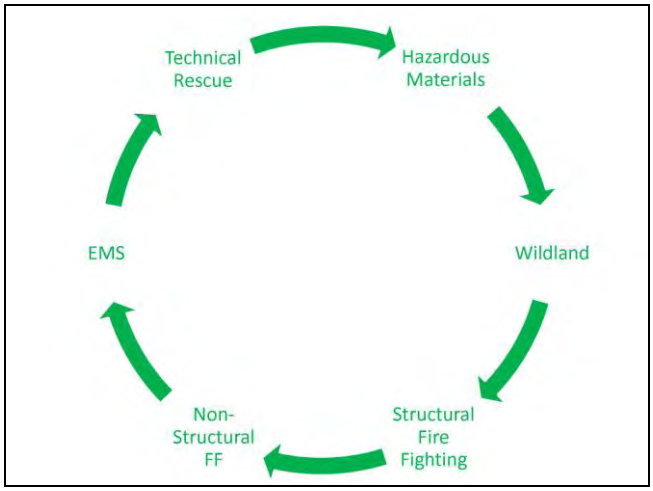

Figure 1-20: Types of Operational Functions Performed by the U.S. Fire Service.

Figure 1-21 is a combination and consolidation of Figures 14 through 1-20. This represents a summary overview of the fire service in the United States, and provides illustrated detail on the organizations that administratively host fire departments (Figure 1-18), the basic types of fire service organizations (Figure 1-19), and types of operational functions that they typically handle (Figure 1-20).

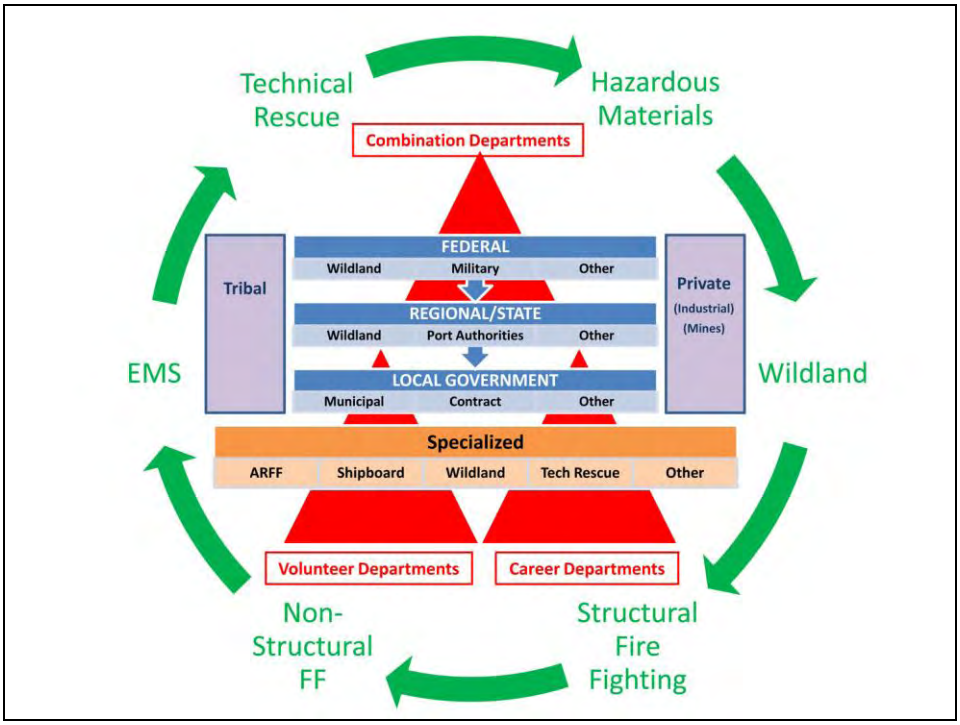

Figure 1-21: Summary Overview of the U.S. Fire Service.

Local, State, and National Resources

A typical emergency first response organization will normally have a variety of sub-units addressing specific functions and tasks. For organizations involved with fire suppression and rescue, a consistent pattern of these sub-units becomes apparent on close inspection.

The basic groups and divisional duties that are generally found within a typical fire/rescue service organization are illustrated in Figure 1-22.[101] These groupings and divisional duties can vary extensively from one particular department to another, especially if the department is small versus a department that is large and has more resources available. The two groups of *Administration* and *Preparedness* provide support for the line function duties handled through *Prevention* and *Response*. Line functions normally refer to activities directly involved with delivering service directly to the department's customers.[102] Generally, the most significant single component of the fire service organization is the *Operations* section handling emergency response, which requires the most equipment and staffing compared to the other groups with the department.[103]

There are multiple resources that support the fire service and related organizations on the regional and national level. These resources have evolved to address certain basic needs of a typical fire service organization, and they address the four basic components of a typical fire service organization of *Administration*, *Preparedness*, *Prevention*, and *Response*, or some combination thereof.

Figure 1-22: Primary Components of a Typical Fire / Rescue Service Organizations [104]

Numerous organizations provide either direct or indirect fire service support, and these have been established and evolved over the years to fulfill a certain express needs. The organizational types are quite varied, and include private non-profit membership associations, trade groups, state or federal government agencies, collective bargaining bodies, commercial enterprises, and so on. Table 1-11 provides a brief summary of a few of the numerous organizations that provide noteworthy direct support for the today's fire service activities.

Table 1-11: Selected Summary of Organizations Related to Fire Service Interests

Association of Public-Safety Communication Officials (APCO) www.apco911.org A membership association with more than 15,000 communications professionals established in 1935 dedicated to public safety communications.
Congressional Fire Service Institute (CFSI) www.cfsi.org A nonprofit, nonpartisan policy institute established in 1989 to educate Members of Congress about fire and life safety issues.
Fire Apparatus Manufacturers Association (FAMA) www.fama.org A non-profit trade association created in 1946 committed to enhancing the quality of the emergency service community through the manufacture and sale of safe, efficient emergency response vehicles and equipment.
Fire Department Safety Officers Association (FDSOA) www.fdsoa.org A non-profit association established in 1989 with a mission to promote safety standards and practices in the fire, rescue and emergency services community.

Fire Equipment Manufacturers and Services Association (FEMSA) www.femsa.org A trade association for the fire and emergency services industry with more than 150 organizational members.

International Association of Arson Investigators (IAAI) www.firearson.com The membership association of investigation professionals, with approximately 9,000 members, with a unified commitment to the suppression of the crime of arson.

International Association of Fire Chiefs (IAFC) www.iafc.org A membership association representing the fire service leadership, serving career and volunteer chiefs, chief fire officers, company officers and managers of emergency service organizations throughout the international community.

International Code Council (ICC) www.iccsafe.org A membership association comprised of building officials and others established in 1994 by the joining of the three U.S. model building code groups, and dedicated to building safety and fire prevention through the development of mode codes residential and commercial buildings.

International Fire Marshals Association (IFMA) www.nfpa.org A membership association organized in 1906 for all lawfully-appointed fire marshals. Operates as a membership section of NFPA.

International Society of Fire Service Instructors (ISFSI) www.isfsi.org A membership organization that provides networking opportunities and resources for fire service instructors.

National Fire Academy (NFA) www.usfa.dhs.gov/nfa/ The training delivery arm of the U.S. Fire Administration located in Emmitsburg, Maryland, dedicated to assisting state and local training programs and for the advanced education of fire service officers.

Metropolitan Fire Chiefs Association (Metro Chiefs) metrofirechiefs2009.com An association for members of IAFC and NFPA who serve as the highest-ranking fire department officers of cities or jurisdictions having a minimum staffed strength of 400 fully paid career fire fighters. This functions as a membership section administered simultaneously by IAFC and NFPA.

National Association of State Fire Marshal's (NASFM) www.firemarshals.org A non-profit membership organization representing the interests of state and provincial fire marshal's.

National Fallen Firefighters Foundation (NFFF) www.firehero.org A non-profit foundation created in 1992 by U.S. Congress to lead a nationwide effort to recognize and remember America's fallen firefighters, and administer programs to honor fallen fire fighters and assist their families and coworkers.

National Fire Protection Association (NFPA) www.nfpa.org A non-profit membership association established in 1896 with about 85,000 members, dedicated to the mission of making the world safety from fire and explosions, and achieving this mission through public education, research, and consensus based model codes and standards.

NFPA Fire Service Section www.nfpa.org A membership section of the NFPA whose objective is to bring together members who are professionally involved in the fire service in support of its role in pursuing the mission of NFPA.

National Volunteer Fire Council (NVFC) www.nvfc.org A non-profit membership association comprised of 49 state volunteer fire fighter organizations and other affiliated members, representing the interests of the volunteer fire, EMS and rescue services.

North American Fire Training Directors (NAFTD) www.naftd.org An international organization that promotes the common interests of providing a quality fire training and educational experience for firefighters, with membership comprised of state fire training directors of each of the fifty states and all Canadian provinces and territories.

PARADE (Prevention Advocacy Resources & Data Exchange) www.usfa.dhs.gov A program of the U.S. Fire Administration created in 2003 that provides regionally based network to foster the exchange of fire-related prevention/protection information and resources among federal, state, and local levels of government, and consisting of the 50 State Fire Marshals, fire marshals from the Nation's largest fire departments, and one representative from each of the 10 Federal FEMA regions.

Society of Fire Protection Engineers (SFPE) www.sfpe.org A membership society established in 1950 representing professionals practicing in the field of fire protection engineering, with approximately 4500 members in the United States and abroad based on 57 regional membership chapters.

U.S. Fire Administration (USFA) www.usfa.dhs.gov An entity of the Department of Homeland Security's Federal Emergency Management Agency, with a mission to foster a solid foundation in prevention,

preparedness, and response by providing national leadership to local fire and emergency services.

U.S. Federal Emergency Management Agency (FEMA) www.fema.gov An agency within the U.S. Department of Homeland Security whose initial beginnings can be traced back to the Congressional Act of 1803, and whose primary mission is to reduce the loss of life and property and protect the United States from all hazards, including natural disasters, acts of terrorism, and other man-made disasters.

U.S. National Fire Academy (NFA) www.usfa.dhs.gov/nfa The national fire training academy administered by the U.S. Fire Administration, to promote the professional development of the fire and the emergency response community and its allied professionals, and support state and local training organizations to fulfill their obligation to the career and volunteer fire and emergency services.

For each of the organizations mentioned above, there are other similar organizations that could likewise be mentioned, and in some cases an appreciable number of additional other organizations. For example, the U.S. federal government has significant resources devoted to fire protection in addition to the four entities mentioned above. Virtually all federal government agencies address fire protection to some extent as part of their normal safety management efforts, and some agencies have a very strong focus specific to fire fighting, such as fire service research at the National Institute of Standards and Technology Bureau of Fire Research Laboratory (www.fire.gov), fire fighter LODD investigations through the National Institute of Occupational Safety and Health (www.cdc.gov/niosh/fire), and wildland fire fighting topics via the U.S. Forest Service (www.fs.fed.us).

Some of these federal government resources are centralized from one location and additionally made available on the local level. For example, the U.S. Federal Emergency Management Agency acts on events of national interest through Washington DC, but they also provide direct assistance to specific municipalities through the local FEMA regional office. The United States is geographically divided into ten regions for this purpose, and these are shown in Figure 1-23.[105]

Figure 1-23: Geographic Regions Used by the U.S. Federal Emergency Management Agency [106]

Another approach to providing a clearer perspective on the number and diversity of organizations serving as resources for the fire service is through a tabulation of the on-going meetings that they annually hold. Table 1-12 provides a summary of fire service oriented membership meetings, conferences, and trade shows in North America. The dates for the 2009 meetings are included in Table 1-12, and although the precise date will change from year to year, this typifies the basic times of the year that these groups generally meet.

Some of these meetings are regional sub-sections of bigger membership organizations (e.g. the New England Division of the IAFC). Others are the primary annual membership meetings for key organizations, and as such have significant attendance numbers for the particular constituents interested in the topic (e.g. FDIC in April, NFPA in June, IAFF bi-annually in August, FRI in August, and so on). It is not unusual for these meetings to focus on certain specific themes, such as the fire fighter training, safety issues, or the built infrastructure. Also, most have venues available for outside speakers to make presentations of interest to the attendees.

Table 1-12: Typical North American Fire Service Meetings, Conferences and Trade Shows

SHOW / MEETING	2009 DATE	LOCATION	FIRST MTG	CONTACT
FDSOA Apparatus Specification & Vehicle Maintenance Symposium	18-21/Jan	Orlando, FL		www.fdsoa.org Fire Department Safety Officers Association
Fire Rescue East	22-23/Jan	Daytona Beach, FL		www.ffca.org Florida Fire Chiefs' Association
Firehouse World	15-19/Feb	San Diego, CA		www.firehouseworls.com Cygnus Business Media
Southwest CAFS Seminar	26-28/Feb	Rosenberg, TX		www.femsa.org Fire Equipment Manufacturers and Services Association
TEEX Annual Spring/ARFF Fire School	1-6/Mar	College Station, TX	1988	www.teex.com Texas A & M Municipal Fire School, Texas Engineering Extension Service
Fire PPE Symposium	9-11/Mar	Charlotte, NC		www.fireppesymposium.com Fire Industry Equipment Research Organization
Annual EDIAFC Conference	14-16/Mar	York, PA		www.ediafc.org Eastern Division International Association of Fire Chiefs
High-Rise Operations Symposium	19-20/Mar	New York, NY	2009	www.nyc.gov/html/fdny New York City Fire Department
Wildland Urban Interface	22-26/Mar	Reno, NV		www.iafc.org International Association of Fire Chiefs
TEEX Annual Arson Investigators Seminar	22-27/Mar	College Station, TX	1955	www.teex.com Texas A & M Municipal Fire School, Texas Engineering Extension Service
Industrial Fire World	23-27/Mar	Beaumont, TX		www.fireworld.com Industrial Fire World
EMS Today Conference & Exposition	24-28/Mar	Baltimore, MD		www.emstodayconference.com Journal of Emergency Medical Services
FAMA Spring Meeting	27-31/Mar	St. Augustine, FL		www.fama.org Fire Apparatus Manufacturers Association (& Fire and Emergency Manufacturers and Services Association

SHOW / MEETING	2009 DATE	LOCATION	FIRST MTG	CONTACT
CFSI Fire Caucus Dinner	1-2/Apr	Washington, DC	1989	www.cfsi.org Congressional Fire Service Institute
Fire 2009: Flammability & Combustibility in Building Materials	6-7/Apr	Chicago, IL	2009	www.principiaconferences.com/conferences/conference.php?confID=12 Principia Partners
FDIC: Fire Department Instructors Conference	20-25/Apr	Indianapolis, IN		www.fdic.com Pennwell Publishing
SAFC Conference	23-25/Apr	Prince Albert, SK		www.safc.sk.ca Saskatchewan Association of Fire Chiefs
IAFF Canadian Legislative Conference	26-29/Apr	Ottawa, ON	1993	www.iaff.org International Association of Fire Fighters
Wildland Fire Safety Summit	27-30/Apr	Phoenix, AZ		www.iawfonline.org International Association of Wildland Fire
Midwest Hazardous Materials Response Conference	1-2/May	Northbrook, IL	1988	EmerySafety.com Emery & Associates, Inc.
OAFC Annual Conference and Trade Show	2-6/May	Toronto, ON	1952	www.oafc.on.ca Ontario Association of Fire Chiefs
Fire-Rescue Med Conference	2-6/May	Las Vegas, NV		www.iafc.org International Association of Fire Chiefs
Station Style Conference	3-5/May	Denver, CO	2005	firechief.com/stationstyle Fire Chief Magazine
Airport Fire – Rescue U.S.A.	4-6/May	Myrtle Beach, SC	2003	www.aviationfirejournal.com Aviation Fire Journal
EDIAFC Conference	14-16/May	York, PA	1927	www.ediafc.org/conference IAFC Eastern Division
Lancaster County FIRE EXPO	15-17/May	Harrisburg, PA		www.lcfa.com Lancaster County Firemen's Association
IAAI Annual Training Meeting	17-18/May	Arlington, TX	1949	www.firearson.com International Association of Arson Investigators
Alberta Fire Chiefs Association Conference & Trade Show	24-25/May	Red Deer, AB	1948	Alberta Fire Chiefs Association
PFANJ Convention & Affiliate Leadership Training Seminar	26-29/May	Atlantic City, NJ		www.pfanj.org Professional Firefighters Association of New Jersey
International Hazardous Materials Response Teams Conference	27-31/May	Hunt Valley, MD		www.iafc.org International Association of Fire Chiefs
2009 Conference & Fire Service Expo	31/May-4/Jun	Namaimo, BC		www.fcabc.bc.ca Fire Chiefs Assoc. of British Columbia
MAFC 2009 Conference and Trade Show	4-6/Jun	Portage la Prairie, MB		www.mafc.ca Manitoba Association of Fire Chiefs
Quebec Association of Fire Chiefs Annual Conference	6-9/Jun	Rimouski, PQ		www.acsiq.qc.ca Quebec Association of Fire Chiefs
IAFF Barbera EMS Conference	7-10/Jun	Miami, FL		www.iaff.org International Association of Fire Fighters
NFPA Conference & Expo	8-11/Jun	Chicago, IL	1896	www.nfpa.org/wsce National Fire Protection Association
Fire 2009: Fire Industry, Rescue, & EMS Expo	10-13/Jun	Verona, NY	1906	www.nysfirechiefs.com New York State Association of Fire Chiefs
SEAFC Annual Leadership Conference	18-20/Jun	Myrtle Beach, SC	1928	Southeastern Association of Fire Chiefs
NASFM Annual Conference	19-21/Jun	Redmond, WA		www.firemarshals.org National Association of State fire Marshal's
Metropolitan Fire Chiefs Conference	21-25/Jun	Edmonton , AB	1965	metrofirechiefs2009.com Metropolitan Fire Chiefs Association

SHOW / MEETING	2009 DATE	LOCATION	FIRST MTG	CONTACT
Health, Fitness and Safety Symposium	23-25/Jun	Phoenix, AZ	1988	Phoenix Fire Department
New England Fire, Rescue & EMS Conference	24-28/Jun	Springfield, MA	1922	www.newenglandfirechiefs.org New England Association of Fire Chiefs
TEEX Escuela en Español	5-10/Jul	College Station, TX		www.teex.com Texas A & M Municipal Fire School, Texas Engineering Extension Service
Missouri Valley Fire Chiefs Conference	8-10/Jul	Overland Park, KS		www.mvafc.org Missouri Valley Division of IAFC
TEEX Industrial School	12-17/Jul	College Station, TX	1963	www.teex.com Texas A & M Municipal Fire School, Texas Engineering Extension Service
South Carolina Fire-Rescue Conference	13-18/Jul	Myrtle Beach, SC	1905	www.scfirefighters.org
TEEX Municipal School Vendor Show	19/Jul	College Station, TX		www.teex.com Texas A & M Municipal Fire School, Texas Engineering Extension Service
TEEX Municipal School	19-24/Jul	College Station, TX	1929	www.teex.com Texas A & M Municipal Fire School, Texas Engineering Extension Service
Firehouse Expo	21-26/Jul	Baltimore, MD		www.firehouseexpo.com Cygnus Public Safety Group
Americas' Fire and Security Expo (AFSE)	29-31/Jul	Miami Beach, FL	2001	www.americasfireandsecurity.com NFPA, and National Association of Hispanic Firefighters
World Police & Fire Games	31/Jul – 9/Aug	Vancouver, BC	1985	www.2009wpfg.ca World Police and Fire Games Federation
APCO Annual Conference	16-20/Aug	Las Vegas, NV	1934	www.apco2009.org Association of Public-Safety Communication Officials
IAFF Membership Convention (Bi-Annual)	22-27/ Aug/2010	San Diego, CA	1918	www.iaff.org International Association of Fire Fighters
Department of Defense Fire & Emergency Services Training Conference	24-28/Aug	Dallas, TX		www.iafc.org International Association of Fire Chiefs
Fire-Rescue International	25-29/Aug	Dallas, TX		www.iafc.org International Association of Fire Chiefs
Incident Management Symposium	27-29/Aug	Phoenix, AZ	1991	http://phoenix.gov/fire/sympos.html Phoenix Fire Department
IAFF Fallen Fire Fighter Memorial	19/Sep	Colorado Springs, CO		www.iaff.org International Association of Fire Fighters
Fire Rescue Canada	20-23/Sep	Winnipeg, MB		www.cafc.ca Canadian Association of Fire Chiefs
FDSOA Annual Conference	21-25/Sep	Orlando, FL		www.fdsoa.org Fire Department Safety Officers Association
Southwestern Fire Chiefs Conference.	25-29/Sep	North Little Rock, AR		www.swd-iafc.org Southwestern Fire Chiefs Association
Pittsburgh Fire/Rescue & EMS Expo	2-4/Oct	Pittsburgh, PA	1987	www.pittsburghfireexpo.com Kelly Simon Productions
National Fallen Fighters Memorial Service	3-4/Oct	Emmitsburg, MD		www.firehero.org National Fallen Firefighters Foundation
FAMA Fall Meeting	8-10/Oct	Arlington, VA		www.fama.org Fire Apparatus Manufacturers Association (& Fire and Emergency Manufacturers and Services Association

SHOW / MEETING	2009 DATE	LOCATION	FIRST MTG	CONTACT
Firehouse Central 2009	26-30/Oct	Atlanta, GA		www.firehousecentral.com Cygnus Public Safety Group
IAFC Volunteer & Combination Officers Symposium	5-8/Nov	Clearwater Beach, FL		www.iafc.org International Association of Fire Chiefs
VCOS Symposium (for Volunteer & Comb. FDs)	5-8/Nov	Clearwater Beach, FL		www.iafc.org International Association of Fire Chiefs
Mexico Fire and Safety Expo	12-14/Nov	Mexico City, Mexico	2004	www.mexicofireandsafety.com National Fire Protection Association
IAFF Redmond Symposium	8-12/Nov	Los Angeles, CA	1958	www.iaff.org International Association of Fire Fighters
IAFC and IAFF Labor Management Initiative	10-11/Dec	Phoenix, AZ		www.iafc.org International Association of Fire Chiefs International Association of Fire Fighters

The meetings, conferences and trade shows represented in Table 1-12 provide a useful venue to reach members of the fire service and related organizations, but other methods of communication such as electronic media and printed media are also effective. For example, most of the organizations indicated in Table 1-11 have printed magazines, membership journals, and other regularly published literature. Some of these publications have appreciable circulations, with a focus consistent with the memberships they serve. Table 1-13 provides a general summary of North American fire service related publications

Table 1-13: General Summary of North American Fire Service Related Publications [107]

PUBLICATION TITLE / NAME	HOST / DISTRIBUTION
9-1-1 Magazine	Tustin, CA : Official Publications, Inc.
All Hands Herald	Borehamwood, England : Paramount Publishiing Ltd.
American City & County	Atlanta, GA : Penton Media
American Journal of Public Health	London England : W. Pearce & Co.
APF : Asia Pacific Fire Magazine	Chicago, IL : Insurance Committee for Arson Control
ASTM Standardization News	West Conshohocken, PA : ASTM International
Atlantic Firefighter	Amherst, Nova Scotia, Canada : Hilden Publishing, Ltd
Building Safety Bulletin	Lancaster, PA : Technomic Publishing Co.
Building Safety Journal	Lancaster, PA : Technomic Publishing Co.
California Fire Service	Washington DC : International Association of Fire Chiefs
Chief	Ashland, MA : The Society of fire Service Instructors
Combustion and Flame	
Consulting-Specifying Engineer	Washington, DC : International Association of Fire Chiefs
Crisis Response Journal	Detroit, MI : The Institute
Disaster Recovery Journal	
Emergency Preparedness News	
ENR: Engineering News Record	Annandale, VA : Washington Fire News Services
Environmental Building News	
Fire	St. Louis MO : Systems Support Inc.
Fire Apparatus	Turnbridge VT : www.fireapparatusmagazine.com
Fire : Journal of the Fire Protection Profession	Mobile, AL : Elevator World.
Fire and Materials : an International Journal	Chicago IL: American Institute of Steel Construction
Fire and Police Personnel Reporter	Cedar Grove, NJ : Fire and Safety Group
Fire Chief	Chicago, IL : Primedia Business
Fire Command & Management	Washington DC : International Association of Fire Fighters
Fire Engineering	Fair Lawn, NJ : Penwall Publishing Company
Fire Engineers Journal	Washington, DC : Forest Service, U.S. Dept. of Agriculture
Fire Fighting in Canada	Simcoe, ON, Canada : www.firefightingcanada.com
Fire Forum	

PUBLICATION TITLE / NAME	HOST / DISTRIBUTION
Fire International	Amityville, NY : Baywood Pub. Co.
Fire Management [electronic resource]	New York, NY : American Society of Civil Engineers
Fire Management Notes [electronic resource]	Washington, DC : U.S. Department of Agriculture, Forest Service
Fire Management Today	
Fire Marshals Quarterly	
Fire News	Bellport, NY : www.firenews.com
Fire Prevention	New York, NY
Fire Protection Contractor	Auburn, CA : www.fpcmag.com
Fire Protection Engineering	
Fire Rescue Magazine	San Diego, CA : Jems Communications
Fire Research	Boulder, CO : University of Colorado
Fire Research	Boston, MA : New England Archivists
Fire Risk Management	
Fire Safety Journal	
Fire Safety, Technology & Management	
Fire Science and Technology	
Fire Services Journal	Ajax, ON, Canada : www.fsj.on.ca
Fire Surveyor	Toronto, Ontario, Canada : Office of the Fire Marshal
Fire Times	Emmitsburg, MD : U.S. Fire Administration
Fire.gov [electronic resource]	Gaithersburg, MD: NIST/BFRL, Natl Institute of Standards & Tech
Firehouse Magazine	New York, NY : Firehouse Magazine Associates
Forest Products Journal	
FS-World.com : Fire and Safety Magazine	Chicago, IL : H.M. Ginn Corp.
Hazardous Cargo Bulletin	
Health & Safety for Fire & Emerg Service Persnl	Fire Department Safety Officers Association
Homeland First Response	Santa Anna, CA : Official Publications
IAEI News	Park Ridge, IL : AELE Law Enforcement Legal Center
IAFC on Scene	Park Ridge, IL : AELE Law Enforcement Legal Center
IFCI Fire Code Journal	Prairie Village, KS : Association of Records Managers & Admin.
Industrial Fire Journal	Chicago, IL : Society of American Archivists
Industrial Fire World	Madison, WI : Forest Products Society
International Fire Fighter	
International Fire Protection	
Intl Fire Service Journal of Leadership & Mngmt	Arcadia, CA : Butane-Propane News Inc
International Journal for Fire Service & Tech.	
JEMS : Journal of Emergency Medical Services	
Journal of Applied Fire Science	
Journal of Consumer Product Flammability	Bethesda, MD : Society of Fire Protection Engineers
Journal of Emergency Management	
Journal of Fire & Flammability	Birmingham, AL : Southern Building Code Congress International
Journal of Fire Protection Engineering	
Journal of Fire Retardant Chemistry	New Haven, CT : American Fire Sprinkler Association
Journal of Fire Sciences	
Journal of Performance of Constructed Facilities	
Journal of Structural Engineering	
Journal of the Fire Service College	Philadelphia, PA : American Society for Testing and Materials
Modern Steel Construction	
Natural Hazards Review	Fort Atkinson, WI : Cygnus Business Media
NFPA Journal	Quincy, MA : NFPA, National Fire Protection Association
SFPE Bulletin	Bethesda, MD : Society of Fire Protection Engineers
Structural Engineer	
Target Arson : Update	Washington, DC : U.S. Govt. Printing Office
Voice	Ashland, MA : International Society of Fire Service Instructors
WFS Quarterly	Women in Fire Suppression
Wildfire	Quarterly Bulletin of the International Association of Wildland Fire
World Fire Statistics	Washington, DC : U.S. Dept. of Agriculture, Forest Service

In addition to printed media, nearly all the organizations supporting the fire service today have websites which they use to make their information broadly available. In some cases, their website is their primary presence, superseding in popularity their respective companion printed publications indicated in Table 1-13.

An example of a recent internet-based activity that has been dramatically successful in a short period of time is the "*National Fire Fighter Near-Miss Reporting System*" (www.firefighternearmiss.com).[108] Only a few years old, this is a free, voluntary, confidential, non-punitive and secure reporting system with the goal of improving firefighter safety. This provides a forum for everyday fire fighters similar to the discussions that currently take place around the kitchen table in every firehouse. The program is funded by the U.S. DHS/FEMA Assistance to Firefighters Grant (AFG) Program, and is administered by the International Association of Fire Chiefs.

4) PERMITTING INFRASTRUCTURE

Most fire service organizations include a component that addresses prevention. This fire prevention component includes any fire service activity whose purpose is to decrease the occurrence and severity of an unwanted fire. This includes inspection of existing facilities, review of plans for new construction, public fire safety education, and post-fire investigations.[109]

A key mechanism used by officials in handling fire prevention duties to assure that a property meets a pre-determined minimum level of safety, is through a permit, inspection and approval process. Permitting allows the appropriate jurisdictional official to assure the level of safety collectively deemed appropriate for the community has been achieved. It provides a mechanism for the designated safety official(s) for that jurisdiction to uniformly and consistently maintain oversight of the applicable occupancies within his or her jurisdiction. It is important that the appropriate jurisdictional official be involved in the planning, implementation and construction process as early as possible.

Jurisdictional Basics

Modern civilization has evolved based on mankind's nature as a social creature. As a collective society, we have checks and balances to assure that the actions of any one person or organization is fair and appropriate in relation to the common good. One such action, and of specific interest here, is the construction of a new building or facility.

Building Safety Evolution

Regulations, laws, guidelines and other oversight measures have evolved so that if someone wishes to construct, erect or install a new building or facility, they must do so in a manner that will not adversely impact themselves, their neighbors, or their community. Concerns that are taken into account include but are not limited to providing safety for individuals, reducing property loss, maintaining tax base, protection of the environment, minimizing public health problems, preserving cultural resources, and upholding national security.[110]

Arguably the oldest and most well-known regulatory code today is the Code of Hammurabi, an ancient statute primarily based on retaliation.[111] King Hammurabi was a famous Babylonian ruler who reigned from approximately 1795 to 1750 B.C., and his code is preserved on an 8-foot-high black stone monument intended for public display to the citizens at that time. After almost four millennia, the basic need that existed in ancient Babylon for regulating safe building construction remains to this day as a fundamental theme in regulatory codes.

Although today we seek to prevent accidents and loss of life and property rather than retaliation, the following decree from the Code of Hammurabi is among those closely related to the same central theme that still exists in today's modern building codes:[112] "*229: If a builder build a house for someone, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.*" Today, someone who does not follow regulations required for construction may be subject to criminal penalties, and in addition, the current legal system through the civil courts serves as the retaliatory arm when negligence is found to be the cause of harm to another individual.

Personal freedom is a fundamental basic right in today's society, and it is constantly balanced against the need to protect public health, safety and welfare.[113] This is the basis for more stringent regulations applying to property where the public has access, such as commercial or mercantile occupancies.

Installations using hydrogen could be incorporated into any particular occupancy classification if an installation provides refueling operations (both public and private, including residential) or a fuel cell power supply (for backup power). The installation of these systems in all occupancies, including one- and two-family dwellings and other residential occupancies, is regulated with a requirement for on-going inspections. For residential use, the jurisdictional requirements vary and need to be further examined on a case-by-case basis.

Tenth Amendment and Dillon's Rule

In the United States, a fundamental power given to States by the Tenth Amendment to the U.S. Constitution is the restraint upon the personal freedom and property rights of an individual for the protection of the public health, safety and welfare. The Tenth Amendment to the U.S. Constitution states the following:[114]

> "*The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved for the States respectively, or to the people.*"
> (U.S. Constitution, Tenth Amendment)

This effectively provides police power to the States, but not to municipalities within the State. An important interpretation of the Tenth Amendment that is often referenced is "Dillon's Rule", a landmark State Supreme Court ruling that extended to other States and still referenced today. This is named after Iowa Supreme Court Judge John Forrest Dillon based on legal case in the late 1800's, and it indicates the following:[115]

> *"local jurisdictions only have powers expressly conferred to them from State constitutions, State statutes, or home rule charters."*
> (Dillon's Rule)

When Dillon's Rule is exercised through a State constitution, State statute or home rule charter, the term "*home rule*" State is used to describe how the State has delegated its authority. Or

described another way, a so-called "*home rule*" State is one that, through legislation, has clearly delegated State authority to the local jurisdiction level.

Once an area within a State becomes incorporated as a city, town or village, certain State powers will generally be transferred to the local level, although the extent of this authority will vary from State to State. In some States, such as those in the Northeast like Massachusetts, every part of the State is incorporated as a city or town. Elsewhere, and especially with the large land-area States in the mid-west and west, the rural areas are unincorporated districts and are served by State government or County government representing the State.

Home Rule and Mini/Maxi

In the United States most states have their own unique state building and fire codes. While these are almost always based on the available national model codes, the final amended document can vary significantly based on local requirements. Some states permit each community to adopt its own fire and building codes in lieu of a state code; this leaves some communities without any fire or building code where no state code exists. Alternatively, some states adopt a state-wide code and allow the local jurisdiction to modify it based on local needs, as long as it is not less restrictive than the state code.

The term "Home Rule" is sometimes used as a general indication of the degree of local authority within that particular state. Home rule allows greater self-government for constituent parts of a state within the greater administrative purview of the central government. This provides them with the authority that they "may exercise any organizational or administrative power, subject only to the constitution and any enactment of the legislature which is of statewide concern and which uniformly affects each county."[116] Table 1-14 provides a status summary of municipal home rule in each state according to the particular constitution of that state.

Table 1-14: Status of Municipal Home Rule According to State Constitution.[117, 118]

STATE	APPLICATION	DATE
Alabama	No provision for Municipal Home Rule	N/A
Alaska	Requires enabling legislation for first class cities and boroughs	1959
Arizona	Self executing for cities of 3,500 or more	1912
Arkansas	Requires legislative statute; for any municipality	1972
California	Self executing for cities (and San Francisco city-county)	1879
Colorado	Self executing for any municipality	1902
Connecticut	Requires enabling legislation for any city, town, or borough	1965
Delaware	Requires legislative statute; for any municipality	1953
Florida	Requires legislative statute; for any municipality	1968
Georgia	Requires legislative statute; for any municipality	1947
Hawaii	Self executing for all political subdivisions	1959
Idaho	No provision for Municipal Home Rule	N/A
Illinois	Self executing for all cities over 25,000; municipalities optional	1971

Indiana	No provision for Municipal Home Rule	N/A
Iowa	Requires enabling legislation for any municipality	1968
Kansas	Self executing for all cities	1960
Kentucky	Requires legislative statute; for cities only	1980
Louisiana	Self executing for any municipality	1974
Maine	Self executing for any municipality	1970
Maryland	Requires enabling legislation for cities and towns	1954
Massachusetts	Requires enabling legislation for cities and towns	1966
Michigan	Requires enabling legislation for each city and village	1908
Minnesota	Requires enabling legislation for any city and village	1898
Mississippi	No provision for Municipal Home Rule	N/A
Missouri	Self executing for any city over 5,000	1875
Montana	Self executing for municipalities; voter review of 5 options (1977)	1972
Nebraska	Self executing for any city over 5,000	1912
Nevada	Requires enabling legislation for any city or town	1924
New	Requires legislative statute; for cities and towns	1966
New Jersey	Requires legislative statute; with optional charter system for	1950
New Mexico	Self executing for municipalities	1970
New York	Requires enabling legislation for cities, towns and villages	1923
North Carolina	Requires legislative statute; for any municipality	1917
North Dakota	Self executing for all cities	1966
Ohio	Self executing for any municipality	1912
Oklahoma	Self executing for any city over 2,000; charter subject to Governor's	1908
Oregon	Self executing for every city and town	1906
Pennsylvania	Requires enabling legislation for optional forms for all local	1969
Rhode Island	Self executing for every city and town	1951
South Carolina	Requires enabling legislation for municipalities	1975
South Dakota	Self executing for any municipality	1962
Tennessee	Self executing for any municipality	1953
Texas	Requires enabling legislation for cities over 5,000	1912
Utah	Self executing for any incorporated city or town	1932
Vermont	No provision for Municipal Home Rule	N/A
Virginia	No provision for Municipal Home Rule	N/A
Washington	Self executing for Any city over 10,000	1889
West Virginia	Requires enabling legislation for municipalities over 2,000	1936
Wisconsin	Requires enabling legislation for cities and villages	1924
Wyoming	Self executing for municipalities	1973

Some State governments preclude the local jurisdictions from adopting any regulations or amendments through a concept known as “mini/maxi”. These mini/maxi State codes provide uniform regulations at the State level that cannot be amended by local counties, cities, towns or villages. Figure 1-24 illustrates the Mini/Maxi concept. The uniformity provided is typically favored for its convenience by builders and developers, but conversely this approach is typically

not favored by local governing bodies as unwelcome oversight into local issues by a State governing body that may be out of touch with local needs.[119]

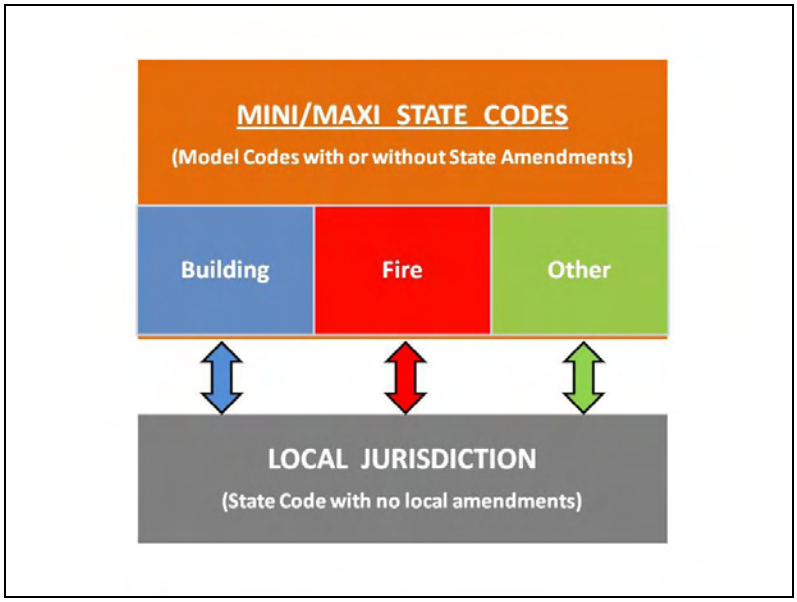

Figure 1-24: Mini/Maxi Concept for Use of State Codes

Defining the Authority Having Jurisdiction

Who is the official that is in charge of fire safety for any particular jurisdiction? A term that is commonly used in model codes and legislative mandates to describe the primary permitting authority is "Authority Having Jurisdiction", or its acronym "AHJ". Specifically, the AHJ is defined as the "organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure."[120]

This term (AHJ) is generally used in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities depending on their legislated scope and powers. The AHJ may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. Multiple individuals or entities may be involved in any particular permitting process.

The AHJ is most commonly recognized as a government enforcer, but it is sometimes applied to others who do not have statutory authority to apply safety provisions. As an example, for insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the AHJ. This may be the result of a contractual relationship.

In many circumstances, the property owner or his or her designated agent assumes the role of the AHJ; at government installations, the commanding officer or departmental official may be the AHJ. There may also be statutory AHJs and non-statutory AHJs involved in the same projects. Figure 1-25 provides an overview of the various statutory and non-statutory individuals/organizations/groups that function as AHJs. The term "code official" is sometimes be used to describe AHJs with statutory authority, and while an AHJ may not be a code official, a code official is always an AHJ.

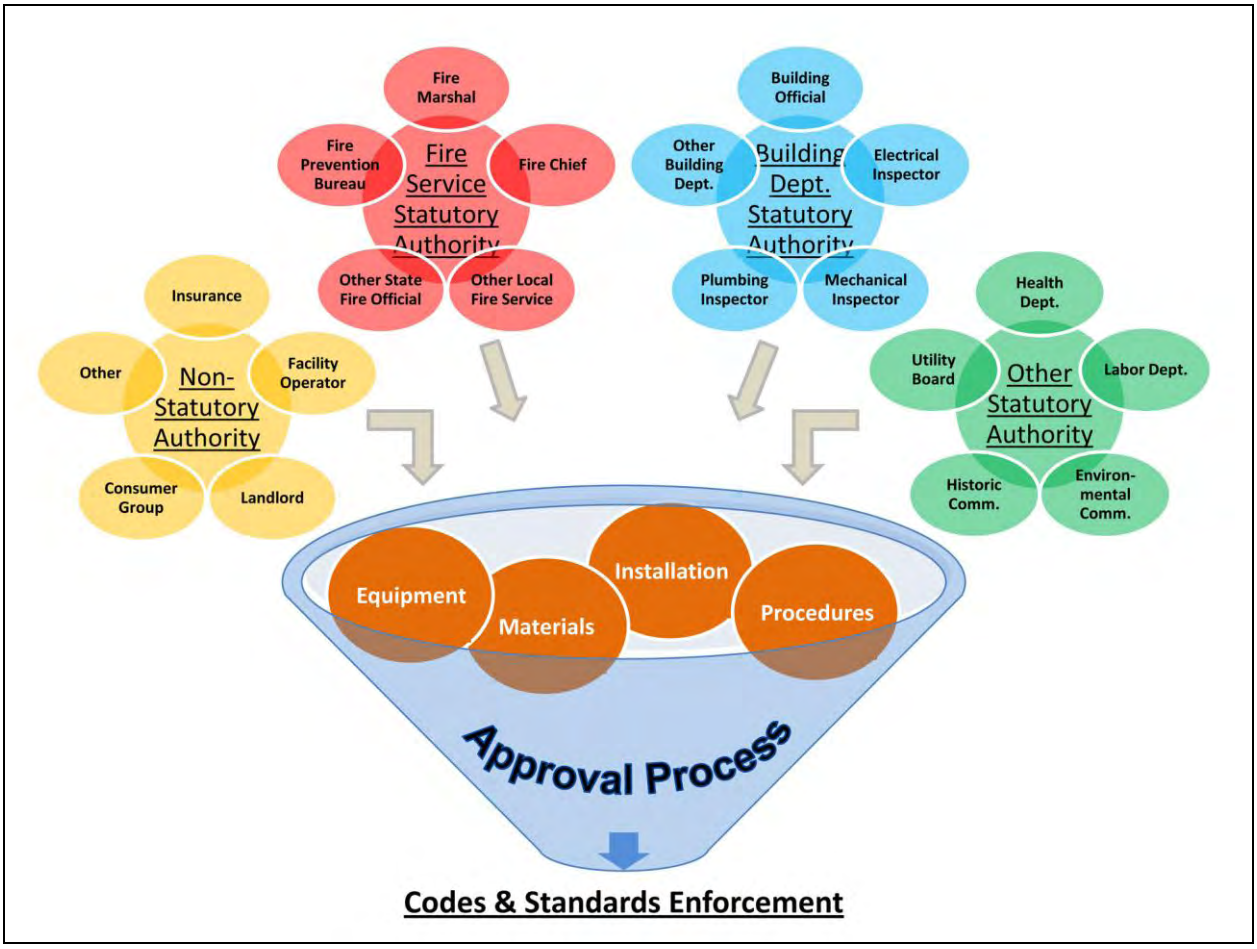

Figure 1-25: Overview of Individuals/Organizations/Groups that Function as AHJs

From the standpoint of any particular use or construction activity requiring a permit, such as a hypothetical hydrogen refueling station or a stationary fuel cell emergency power supply for telecommunications, the permitting process will likely require the submission and approval of multiple AHJs. For sake of discussion and simplification, consider a typical permitting effort by first excluding non-statutory empowered AHJs (like insurance organizations) for simplification. Here the permitting effort might require the following review, which is also illustrated as an example in Figure 1-26:

- local community fire marshal for the fire department,
- local community building official, and
- state fire marshal's office.

In addition, the permitting effort may involve a range of other agencies of groups. Examples include a planning & zoning board, public utility committee, environmental protection or conservation commission, hazardous materials review committee, historic preservation foundation, or other groups with a narrowly defined subject area that requires reviews and permits.

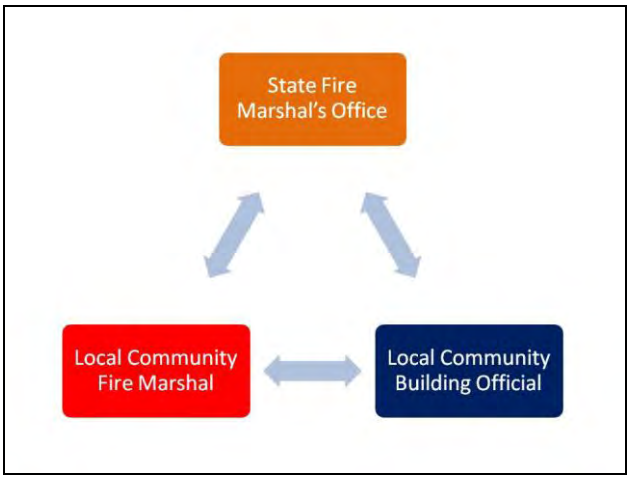

Figure 1-26: Fundamental Components of a Typical Permitting Process

One AHJ that is often mentioned in the permitting process for new and existing buildings is the Fire Marshal. These officials at the local level are often directly related to the fire service, and at the state level they usually maintain strong liaison relationships on multiple activities with the fire service organizations in their state. For applications involving the use of a hazardous material, such as a flammable gas like hydrogen, the Fire Marshal and other fire service representatives are usually the key permitting officials involved in the approval process.

A Fire Marshal is defined as "a person designated to provide delivery, management, and/or administration of fire protection and life safety related codes and standards, investigation, education, and/or prevention services for local, county, state, provincial, federal, or private sector jurisdictions as adopted or determined by that entity."[121] The term has also been defined in other sources, as "the head of a governmental department or an office charged with the prevention and investigation of fires", and as "the principal fire prevention officer of a state, county, or city".[122, 123] In some cases, another jurisdictional official performs a job function consistent with the above definition of a fire marshal but uses a different professional title (e.g., Chief, Commissioner, Engineer, etc), and for all practical purposes are understood to be the applicable "Fire Marshal".[124]

Most states have a statutory official designated as the "State Fire Marshal" (SFM). The organizational structure of the resources they administer varies considerably from state to state. In North America there is appreciable interaction between the State Fire Marshals of the United States and the Provincial Fire Marshals in Canada.[125] In some States and Provinces this position is synonymously referred to as the State or Provincial Fire Commissioner.

Most of these were established in the early 1900s, and in some cases these positions were created as the result of a devastating fire in that particular state. The earliest U.S. appoint of an official role similar to the duties of a modern SFM is considered to be the 1689 appointment of Brent Masters for New York City (which at that time was known as New Amsterdam).[126] The first individuals appointed under the current designation of SFM occurred in 1894 for the states of Massachusetts and Maryland. Today, the SFM's office answers to different branches of state government, i.e. Public Safety, Insurance, State Police, State Cabinet, or other government agency.[127]

Background on Fire Prevention Resources

The fire service is almost always the primary organization in the local community tasked with assuring that the minimum levels of public safety from hazards involving fires and explosions are in place. For hazardous materials, such as a flammable gas like hydrogen, the Fire Marshal or other fire service representative provide an initial checkpoint in the overall permitting process. Other agencies, organizations, boards and commissions are often involved, though their focus generally is on safety aspects like structural integrity or public health, and on non-safety issues such as the protecting the environment or historic preservation.

From a fire prevention standpoint, the local fire service is nearly always involved with the oversight of installations handling hazardous materials, and this is frequently done through a permitting process. In addition, the fire service at the County or State level may have some level of direct or indirect involvement. For any fire service organization addressing fire prevention issues, the four basic tasks that require attention and dedicated resources are:[128]

1) review of existing buildings with Fire Inspectors,
2) review of new buildings with Plan Examiners,
3) providing public education programs with Public Fire & Life Safety Educators, and
4) Investigating fire events with Fire investigators.

These basic tasks are summarized in Figure 1-27, and they illustrate the resources devoted at the local and state levels (and in some cases on the county level rather than state level). It should it be noted that these basic tasks are addressed by the NFPA professional qualification standards summarized earlier in Figure 1-11 (i.e., NFPA 1031, 1033, 1035, & 1037), and they provide the baseline for the primary job tasks of the professionals within these fire prevention units. Certain additional individuals may also support these activities, including Fire Protection Engineers who provide a high level of technical support for plans review and other highly detailed technical issues, and Fire Data Analysts who collect and process the necessary data addressing fire protection concerns in that particular jurisdiction.

At both the local and state levels, Fire Marshals and their support staffs will generally network to clarify the best operating approaches and optimum practices. Several membership groups

provide important resource support for these professionals. These were collectively mentioned earlier in Table 1-11, and three of particular interest to Fire Marshals are:

NASFM: National Association of State Fire Marshal's (A non-profit membership organization representing the interests of state and provincial fire marshal's);
IFMA: International Fire Marshals Association (A membership association organized in 1906 for all lawfully-appointed fire marshals. Operates as a membership section of NFPA);
PARADE: Prevention Advocacy Resources & Data Exchange (A program of the U.S. Fire Administration created in 2003 that provides regionally based network to foster the exchange of fire-related prevention/protection information and resources among federal, state, and local levels of government, and consisting of the 50 State Fire Marshals, fire marshals from the Nation's largest fire departments, and one representative from each of the 10 Federal FEMA regions).

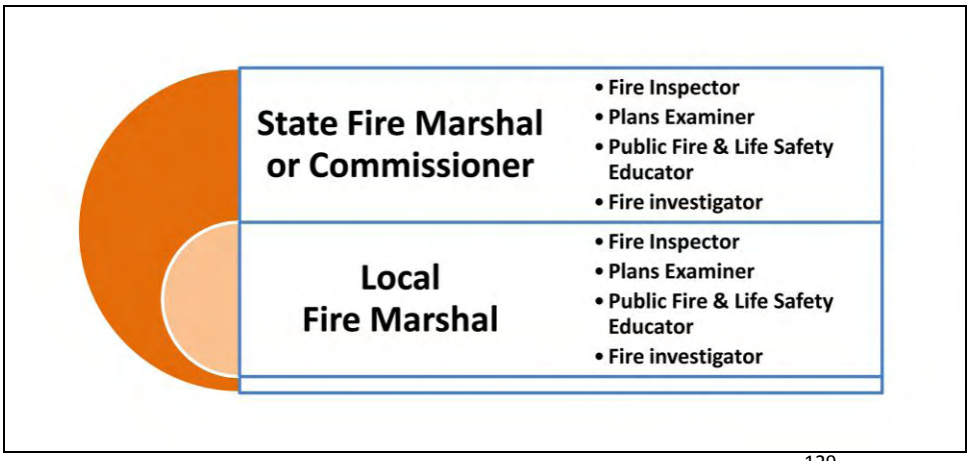

Figure 1-27: Summary of Fire Prevention Personnel [129]

The extent to which plan reviews and permitting services are provided by a local fire service organization varies depending on the size of the community. On average, for the 2005 time frame approximately half of the local fire service organizations in the United States provided plan reviews, and more than one quarter had a permit approval process.[130] Table 1-15 clarifies the percent of fire departments that provide plans review and permit approval by population size.

An important point to consider from the data presented in Table 1-15 is the sharp drop in fire department involvement in lesser populated districts. Local fire department oversight varies considerably depending on whether it is a populated urban area or a more sparsely populated rural district. For jurisdictions with a protected population of 50,000 or more, the likelihood of plan reviews conducted by the local fire department is in the 90 percentile, and the likelihood of a fire department permit approval process is in the 80 percentile.

In terms of baseline population, 2005 data indicates an estimated 67.0 million U.S. residents (23 percent of total U.S. population) are protected by fire departments that do not conduct plan

reviews, and an estimated 118.9 million (40 percent of total U.S. population) are protected by departments that do not have a plans approval process.[131] However, each of these services may actually be provided by another agency or organization in these communities, and thus this data should not be interpreted to mean that these services are non-existent in these jurisdictions.

Table 1-15: Percent of Fire Department Plans Review and Permit Approval by Population Size [132]

Population Protected	PERMIT APPROVAL Provided by Local Fire Department (%)	PLANS REVIEW Provided by Local Fire Department (%)
1,000,000 or more	70.0	70.0
500,000 to 999,999	89.3	92.9
250,000 to 499,999	89.1	97.8
100,000 to 249,999	83.4	92.3
50,000 to 99,999	80.5	94.3
25,000 to 49,999	66.1	89.3
10,000 to 24,999	48.1	78.1
5,000 to 9,999	28.6	62.4
2,500 to 4,999	18.0	45.8
Under 2,500	19.1	36.8
Total	27.0 %	50.1 %

Where fire code inspections are being performed, which entities are conducting these inspections? Table 1-16 summarizes data for the calendar year 2005, as to who is conducting fire code inspections based on population. Once again this data indicates a sharp drop in fire department involvement in lesser populated districts, particularly in more rural jurisdictions with a protected population of 10,000 or less.

Table 1-16: Percent of Who Conducts Fire Code Inspections by Population Size [133]

Population Protected	Full Time Fire Dept. Inspectors (%)	In-Service Fire Fighters (%)	Building Dept.	Separate Inspection Dept.	Other	No One
1,000,000 or more	100.0	70.0	10.0	0.0	0.0	0.0
500,000 to 999,999	92.9	64.3	3.6	3.6	0.0	0.0
250,000 to 499,999	100.0	54.3	10.9	0.0	2.2	0.0
100,000 to 249,999	97.0	49.7	12.4	2.4	1.2	0.0
50,000 to 99,999	91.0	51.8	14.7	4.0	4.0	1.0
25,000 to 49,999	74.0	46.0	19.3	3.4	13.6	1.6
10,000 to 24,999	47.6	37.9	22.3	7.9	19.5	4.3
5,000 to 9,999	20.4	22.8	24.6	10.3	28.7	13.8
2,500 to 4,999	9.6	17.3	19.7	14.3	28.3	23.7
Under 2,500	4.0	11.6	13.0	14.5	25.2	36.6
Total	17.3 %	19.5 %	17.1 %	12.4	24.5	25.2

In addition to the local fire service organization, other local government agencies may also have a significant role in assuring safe building construction practices. Primary among these is the local Building Department, and they are a particularly important oversight body for new construction. This department is generally led by the municipal Building Official, and is often a

separate entity from the fire service and emergency response organizations. Nevertheless, they provide safety oversight similar to the fire prevention section of the local Fire Marshal's office.

While the fire service is significantly focused on fire and explosion safety for occupants and emergency responders, the Building Department is not only concerned with these same hazards, but with all other aspects of construction, including but not limited to structural stability, public health, environmental protection, energy conservation, aesthetics, and protection against for natural and man-made disasters (earthquakes, severe wind, snow load, wildfire, etc).[134]

Building Department representatives are generally involved with certain baseline code requirements of the permitting process, such as the administration of "height and area" requirements (limitations of a buildings height and area depending on multiple factors), and siting or zoning set-backs. The Building Department usually includes inspectors specializing in certain disciplines, such as electrical work, mechanical work, and plumbing work.

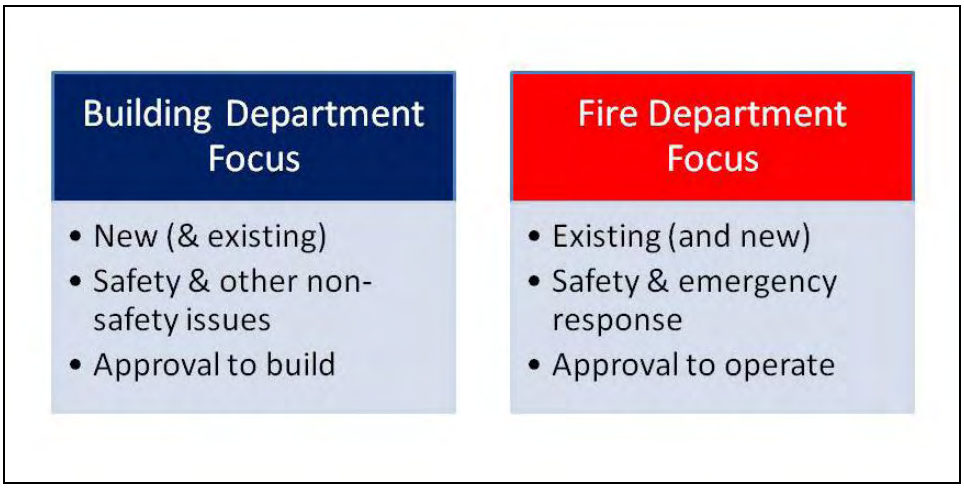

Figure 1-28: Focus of Typical Building and Fire Departments

Normally the key groups involved with safety issues through the permitting and code administration/enforcement process are the Fire and Building Departments. Figure 1-28 illustrates the general focus of each of these departments. However, additional groups may be part of the permitting or approval process depending on the jurisdiction. Some examples include a separate Planning & Zoning Board, Environmental Commission, or Public Health Committee. Approvals from other groups may also be required for issues other than safety, such as a Historic Commission in a historic district, or a Public Utilities Board approving the location of public utilities. In summary, the specific groups involved with the permitting process vary significantly from jurisdiction to jurisdiction, although it almost always includes the local Fire and Building Departments.

Codes and Standards Overview

The Tenth Amendment to the U.S. Constitution states, "*The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved for the States respectively, or to the people.*"[135] This defining statement defers certain matters (including public safety in appropriate circumstances) away from the federal government and gives them to every state.

Specifically, these powers include placing restrictions on building construction to assure minimum levels of health, safety and welfare. These are accomplished through local legislative means by adopting zoning laws, height and area restrictions, municipal ordinances, and smart growth laws.[136] Subsequently each state has developed its own unique state building and fire codes, and the safety infrastructure (and associated de-centralized permitting processes) rather than one standardized set nationwide.

In the United States almost all states, counties, cities and towns that have adopted construction codes enact and enforce them under their police powers to promote the health, safety and general welfare of its citizens. Nearly all states have a State Building Code, which normally distinguishes between new construction and existing buildings, and includes an appeal process.

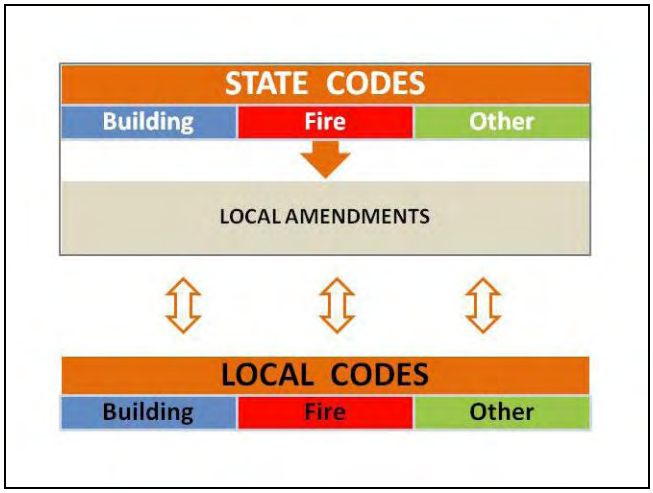

Figure 1-29: State and Local Codes Overview

Most states also have a State Fire Code, which is a critical companion document alongside the Building Code, and has a particular focus on protecting the public's safety and health. The Fire Code is a key tool used by fire inspectors for the on-going enforcement of reasonable levels of fire safety throughout the lifespan of a building.[137] Some states permit each community to adopt its own fire and building codes in lieu of a state code; this leaves some communities without any fire or building code where no state code exists. Figure 1-29 provides a simplified overview of the possible interrelationship between the state and local codes.

A subtle distinction exists between the use of the two terms "Code" and "Standard". Generally speaking, a code describes what must be done and a standard describes how to do it. A code is broad in scope and contains less specific detail; a standard has a narrow scope and contains relatively more detail. For example, NFPA 101, *Life Safety Code®* requires that all new one and two family dwellings be protected by an automatic sprinkler system.[138] It describes what must be done, and refers to NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.[139] NFPA 13D describes the technical details for designing, installing and maintaining a residential automatic sprinkler system.

A code is a law or regulation that sets forth minimum requirements. Specifically, a Building Code is a law or regulation that sets forth minimum requirements for the design and construction of buildings and structures, and where they are required (i.e. scoping). In similar fashion, other types of codes address the specific topics indicated by their title (i.e., electrical, mechanical, plumbing, etc).[140]

A standard typically provides specific technical requirements for achieving the desired result, i.e., indicating "how" something must be done in terms of an installation or process. While codes address broad overarching topics, standards provide significant technical detail on a specific subject, with the necessary precision to facilitate the applicable design or installation.[141] Because of their broad application codes are generally adopted into law (e.g. State Building Code), with or without specific amendments, and they in turn provide mandatory and non-mandatory references to many hundreds of standards that likewise indirectly become part of the legislative requirements.

Table 1-17: Codes & Standards Documents and Developing Organizations in the United States [142]

	Developer / Organization	# of Standards	Percent	# of Organizations	Percent
Private Sector	Codes & Standards developing organizations	17,000	18	40	6
	Trade association	16,000	17	130	19
	Scientific and professional societies	14,000	15	300	43
	Developers of informal standards	3, 000	3	150	21
	Private Total	49,000	53	620	89
Federal Govt	Department of Defense	34,000	37	4	1
	General Services Administration	2,000	2	1	1
	Other	8,000	8	75	10
	Federal Government Total	44,000	47	80	11
	Overall Total	93,000	100	700	100

The codes and standards that are applied and enforced by the AHJ in any particular jurisdiction are adopted into law by the respective legislative body for that jurisdiction. The respective legislative body also specifies which entity or individual is the AHJ. The general approach taken by those authorized to establish the minimum code requirements in that jurisdiction is to adopt an applicable model code or standard, with amendments where necessary and appropriate.

Alternatively, a few jurisdictions write their own codes at the state, county or local level, although they typically start with one or more of the national model codes as a starting point. Local ordinances or regulations that sometimes further modify the adopted codes and standards do so by adding detail or making them more stringent.

Table 1-18: Sample of Model Codes and Standards for a Hydrogen Refueling Station [143]

Application	Type	Subject	Developer / Document*
Refueling Station	Design & Installation	Siting and Set-Backs	ICC-IFC, NFPA 1, 52 & 55
		On-Site Production	ICC-IFGC, NFPA 52 & 54
		Fire Safety Equipment	ICC-IFC & IFGC, NFPA 1, 52 & 54
		Dispensing Equipment	CGA G5.5, ICC-IFC, NFPA 1, 30A & 52
		Operations & Maintenance Equip.	CGA G5.5, ICC-IFC, NFPA 1, 30A & 52
		Storage & Compression Equip.	CGA PS20 & PS21, ICC-IFC, NFPA 1, 52 & 55
		Dispensing	ICC-IFC, NFPA 1, 30A & 52, SAE J2600
		Balance-of-Plant Components	ASME B31.3, ICC-IFC & IFGC, NFPA 1, 52 & 54
	Operation & Maintenance	Vehicle Access	ICC-IFC, NFPA 1, 30A, 52 & 55
		Hydrogen Delivery & Unloading	ASME B31.8, CGA P12, ICC-IFC, NFPA 1, 52, 55
		Ignition Control	ICC-IFC, NFPA 1 & 55
		Fire Safety & Emergency Planning	ICC-IFC, NFPA 1, 30A, 52 & 55
		Personnel Issues & Training	ICC-IFC, NFPA 1, 30A & 55
		Dispensing	ICC-IFC, NFPA 1, 30A & 52
		Signage	ICC-IFC, NFPA 1, 52 & 55
		Periodic Inspections	CGA G5.4 & G5.5, ICC-IFC, NFPA 1 & 52

* The following Notes apply to this Table.

NOTE 1: As referenced at "Permitting Hydrogen Facilities", U.S. Dept. of Energy, Washington DC, Website: www.hydrogen.energy.gov/permitting, cited: 22 Apr 2009.

NOTE 2: Documents are continually under revision and subject to change and update.

NOTE 3: This list is not all inclusive, and other documents are also applicable, including numerous other codes and standards mandatorily referenced by these documents (e.g., NFPA 70: National Electrical Code, numerous UL Standards, etc)

NOTE 4: The documents abbreviated in the Table include the following:

- **ASME B31.3: Process Piping (American Society of Mechanical Engineers, 2006)**
- **ASME B31.8: Gas Transmission and Distribution Systems (American Society of Mechanical Engineers, 2003)**
- **CGA G-5.4: Standard for Hydrogen Piping Systems at Consumer Locations (Compressed Gas Association, 2005)**
- **CGA G-5.5: Hydrogen Vent Systems (Compressed Gas Association, 2004)**
- **CGA P-12: Safe Handling of Cryogenic Liquids (Compressed Gas Association, 2005)**
- **CGA PS-20: Direct Burial of Gaseous Hydrogen Storage Tanks (Compressed Gas Association, 2006)**
- **CGA PS-21: Adjacent Storage of Compressed Hydrogen and Other Flammable Gases (Compressed Gas Association, 2005)**
- **ICC-IFC: International Fire Code (International Code Council, 2006)**
- **ICC-IFGC: International Fuel Gas Code (International Code Council, 2006)**
- **NFPA 1: Fire Code (National Fire Protection Association, 2009)**
- **NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages (National Fire Protection Association, 2003)**
- **NFPA 52: Vehicular Fuel Systems Code (National Fire Protection Association, 2006)**
- **NFPA 54: National Fuel Gas Code, ANSI Z223.1 (National Fire Protection Association, 2009)**
- **NFPA 55: Standard for Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks (National Fire Protection Association, 2005)**
- **SAE J2600: Compressed Hydrogen Surface Vehicle Refueling Connection Devices (Society of Automotive Engineers, 2002)**

Private, voluntary codes and standards organizations develop model documents in the United States that have significant benefits for adopting authorities. In particular they are efficient, cost-effective, technically competent, and achieve broad consensus input that results in robust ad well-founded safety requirements. The federal government recognizes these benefits and requires (through Public Law 104-113, H.R. 2196, National Technology Transfer and Advancement Act of 1996) that federal agencies use and actively participate in private

voluntary codes and standards activities, rather than write their own codes and standards directly.[144]

A vast, diverse and decentralized network of private codes and standards developers exists around the world today, and in the United States the codes and standards community maintains an inventory of almost 100,000 documents covering a great range of topics.[145] Table 1-17 provides a summary of the Codes and Standards documents and developers in the United States. It includes model documents developed by private codes and standards developers, and documents developed directly by the federal government.

Table 1-19: Sample of Model Codes and Standards for a Stationary Fuel Cell Power Supply [146]

Application	Type	Subject	Developer / Document*
Stationary Fuel Cell Emergency Power Supply	Design & Installation	Siting and Set-Backs	ICC-IFC & IFGC, NFPA 1, 52, 54 & 853
		Fire Safety Equipment	ANSI FC1, ICC-IFGC & IMC, NFPA 1, 54, 55, 853
		Compressed Hydrogen Gas Storage	ICC-IFC & IMC, NFPA 1, 54, 55 & 853
		Electrical Equipment	ANSI FC1, ICC-IFGC & IMC, NFPA 1, 54, 55, 853
		Fuel Lines	ANSI FC1, NFPA 55 & 853
		Balance of Plant Components	ANSI FC1, ICC-IFGC & IMC, NFPA 1, 54, 55, 853
	Operation & Maintenance	Vehicle Access	ICC-IFC, NFPA 1 & 55
		Hydrogen Delivery & Unloading	CGA P1, ICC-IFC, NFPA 1 & 55
		Fire Safety & Emergency Planning	NFPA 55 & 853
		Personnel Issues & Training	CGA P1, ICC-IFC, NFPA 1 & 55
		Signage	ANSI FC1, ICC-IFC, NFPA 1, 55 & 853
		Periodic Inspections	ANSI FC1, ICC-IFC & IFGC, NFPA 1 & 54

* The following Notes apply to this Table.

NOTE 1: As referenced at "Permitting Hydrogen Facilities", U.S. Dept. of Energy, Washington DC, Website: www.hydrogen.energy.gov/permitting, cited: 22 Apr 2009.

NOTE 2: Documents are continually under revision and subject to change and update.

NOTE 3: This list is not all inclusive, and other documents are also applicable, including numerous other codes and standards mandatorily referenced by these documents (e.g., NFPA 70: National Electrical Code, numerous UL Standards, etc)

NOTE 4: The documents abbreviated in the Table include the following:

- **ANSI FC1 (ANSI/CSA America FC1): Stationary Fuel Cell Power Systems (American National Standards Institute and Canadian Standards Association, 2004)**
- **CGA P1: Safe Handling of Compressed Gases in Containers (Compressed Gas Association, 2006)**
- **ICC-IFC: International Fire Code (International Code Council, 2006)**
- **ICC-IFGC: International Fuel Gas Code (International Code Council, 2006)**
- **ICC-IMC: International Mechanical Code (International Code Council, 2006)**
- **NFPA 1: Fire Code (National Fire Protection Association, 2009)**
- **NFPA 52: Vehicular Fuel Systems Code (National Fire Protection Association, 2006)**
- **NFPA 54: National Fuel Gas Code, ANSI Z223.1 (National Fire Protection Association, 2009)**
- **NFPA 55: Standard for Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks (National Fire Protection Association, 2005)**
- **NFPA 853: Standard for the Installation of Stationary Fuel Cell Power Systems (National Fire Protection Association, 2007)**

Despite the daunting overall number of model codes and standards available for adoption and use in the United States, a limited and reasonable number are directly applicable to applications involving hydrogen, such as a refueling station or stationary fuel cell emergency power supply. A review of the applicable codes and standards for these two applications provides a helpful example of the complexities of technical safety concerns typically confronting an AHJ during a permit approval process. Tables 1-18 and 1-19 provide a brief summary of some of the model codes and standards that address these two hydrogen

applications (with planning & zoning and certain other related code issues not included in these tables). This information is taken from a U.S. Department of Energy website that addresses these hydrogen applications for AHJs and others.[147]

The documents mentioned in Tables 1-18 and 1-19 are only a short sample list of the more widely used model codes and standards documents applicable to these hydrogen applications. There are numerous other documents that may also be applicable, including various documents that provide specific technical details on important sub-topics.[148] One example would be that electrical wiring for the building lighting be in accordance with NFPA 70, *National Electrical Code®*.[149] Many other documents address a wide spectrum of products used within these facilities that might be adopted to provide a reasonable level of quality for critical components (e.g. UL product standards). Many of these are included through mandatory references providing in the overarching documents mentioned in Tables 1-18 and 1-19.

In certain codes and standards, the document scopes are coordinated to collectively provide the requirements necessary to address a particular topic. For example, NFPA 52, Vehicular Fuel Systems Code provides requirements or gaseous or cryogenic liquid hydrogen refueling stations, but if the refueling station also utilizes other fuels (e.g. gasoline, diesel, CNG, etc), then the applicable document is NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages, which is turn references NFPA 52 for the specific portions of the facility that handle hydrogen.[150, 151]

It's important to keep in mind that the model codes and standards used for legislative adoption are under continual review and update. The documents in Tables 1-18 and 1-19 are generally on a repeating three year revision cycle, with a new edition every 3 years. This helps to facilitate and promote new technology and methods that continue to improve and better address the needs of the end user community. One example of this is a recent presentation that clarified the applicability of model codes and standards for an indoor hydrogen refueling arrangement for industrial lift trucks.[152] Analyses of this type provide very helpful and useful information for AHJs faced with similar applications.

Methods and Measures for Inspection and Enforcement Overview

Traditionally, the review of plans and the inspection of new construction tended to be more a function of the Building Department, and the inspection of existing buildings tended to be more a function of the Fire Department. However, today the fire service typically has a more direct role in the plan review and inspection of new construction in addition to the inspection of existing facilities. This is especially true for facilities with hazardous materials such as hydrogen.

There are several mechanisms used by code officials to achieve code compliance. One of the primary mechanisms is through a permitting process. A permit is an official document issued by an AHJ to authorize a specific activity or event. They are the method of choice for authorizing the use, handling, storage, manufacturing, occupancy, or control of specific

hazardous operations and conditions. Permits are also used for the installation of fire protection equipment, special events, or other fire prevention related activities.[153]

Other approaches include the use of certificates, which is a written document that grants permission to conduct or engage in any operation or act for which certification is required. Yet another is through a license, which is generally used to grant permission to engage in a business, occupation, or other lawful activity. These methods are applied with the force of law, using progressive enforcement strategies including Warnings, Notices of Violation, Condemnation Notices, Citations, Summonses, and/or Warrants.[154]

It may seem obvious that all buildings in a jurisdiction should be processed through a permitting and inspection system, but this is not always the case. In certain situations, a different AHJ may have responsibility and a different set of code requirements may be applicable. For example, a state or federal building in a particular jurisdiction may have to comply with the respective state or federal code requirements that apply, but they do not necessarily have to comply with the local jurisdictional requirements.

As a specific example, a building owned by the U.S. Postal Service in any particular jurisdiction must follow the applicable federal requirements, but the host state or local jurisdiction has no authority over them. This becomes even more complex for buildings that are rented or leased, and generally the applicability of code requirements is contingent on who owns the particular facility. Some specific installations may be under the jurisdiction of another agency, e.g. siting of a cell phone tower, which supersedes local requirements.

A critical detail of the permitting process is the siting of a new building or installation, which would involve set-backs and other zoning requirements. This sometimes involves the local Fire Department, the local Building Department, local Conservation Commission, and/or local Zoning Board.

From a fire or explosion standpoint, the siting of the facility and related equipment is one of the most fundamental tools within the fire protection arsenal. There must be adequate safe distances between a property and adjacent exposures, and features that will mitigate potential collateral damage (such as fire spread) during a catastrophic event. Siting issues take into account a multiple safety oriented details, such as adjacent exposures to a fire or explosion, fire department access, and location of water supply.[155]

The use of a hazard analysis process is a helpful tool for an AHJ when considering an application involving hazardous materials. The purpose of the hazard analysis is to identify potential hazards. Several useful approaches for mitigating some hazards have evolved from the petrochemical and transportation industries.

The hazard analysis approach provides a systematic way of addressing complex applications by addressing not only the obvious hazards of an unwanted fire or explosion, but by also addressing the additional dangers of hydrogen such as an asphyxiate, extremely cold

temperature burns from cryogenic liquids, high pressure storage vessels, energized electrical equipment, etc. Some of the common methodologies used today include:[156]

- FMEA: Failure Modes and Effects Analysis, for identifying failure effects;
- HAZOP: Hazard and Operability Analysis, used to identify safety-critical operations activities; and
- PHA: Preliminary Hazard Analysis, which is a method for identifying top-level system hazards.

The adoption, administration and enforcement of fire-related codes and standards is one of the principal strategies fire departments use to reduce the frequency and severity of fires. The overall goal of the code compliance effort and the permitting process is to assure that every provision of every code and standard is complied with in every applicable property.[157] However, in reality this is difficult to achieve, even with the on-going efforts of many building and fire safety professionals who dedicate their careers toward meeting this goal. The progress and success of these efforts are measured according to the following three stages of program evaluation:[158]

- Outcome Evaluation, which measures fire loss;
- Impact Evaluation, which measures the presence of a hazard; and
- Process Evaluation, which measures the quantity and quality of service provided.

5) INCIDENT RESPONSE INFRASTRUCTURE

The emergency response infrastructure in the United States is advanced to the point where any reported incident at any location can be expected to have a response. This is true even in remote areas where response time could be significant. The individual organizations and units composing this infrastructure have evolved to a point where they are able to effectively communicate among themselves and support one another, if necessary, through automatic mutual aid.

The physical attributes of hydrogen make it an ideal fuel, but also introduce the risk of a flammable gas fire or explosion. From the perspective of emergency first responders, hydrogen is considered a hazardous material requiring attention to assure its safe handling. An event involving hydrogen can occur anywhere, not only at predictable, fixed locations such as a refueling station or stationary fuel cell emergency power supply, but at almost any location involving automotive vehicles, transportation delivery trucks, industrial lift trucks, rail transport vehicles, etc.

Sufficient incident response to possible adverse events is critical if the future use of hydrogen is expected to proliferate. Public confidence could be seriously undermined if catastrophic disasters captivate public attention, and the perceived dangers of using hydrogen as a fuel outweigh possible perceived benefits in the public conscience. Thus, the safe application of hydrogen is very important, and likewise adequate incident response to any significant event requiring the emergency response infrastructure is equally important.

Hazardous Material Operations

A hazardous materials incident can often be a significant challenge for emergency first responders. A "hazardous materials" incident is also equally referred to in the incident response community vernacular as a "hazmat" incident. A hazardous material is defined in NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents* as follows:[159]

> *"Hazardous Material. A substance (either matter — solid, liquid, or gas — or energy) that when released is capable of creating harm to people, the environment, and property, including weapons of mass destruction (WMD) as defined in 18 U.S. Code, Section 2332a, as well as any other criminal use of hazardous materials, such as illicit labs, environmental crimes, or industrial sabotage."* (NFPA 472 – 2008, section 3.3.28)

When first responders are initially notified of an emergency situation, the information from the reporting party is generally limited. Response from the fire service is usually based on general information such as a reported fire or motor vehicle crash. Upon arrival one of their first steps will be to assess the situation and identify and confirm the involvement of a hazardous material such as hydrogen.

From an operations standpoint, multiple sources of information are available to emergency first responders to assist them with handling a hazmat incident, though certain information provides a helpful baseline of knowledge. For example, a widely used publication mentioned earlier that is used by emergency first responders for hazardous materials in the United States is the "Emergency Response Guidebook". The extensive use of this publication is that it is not allowed to be sold or re-sold, and is provided free of charge in the United States by the U.S. Department of Transportation. This has resulted being found on most emergency first vehicles used by the fire service and other agencies.[160]

A basic initial step to mitigate the impact of an adverse situation involving hydrogen fuel is isolation.[161] For any event involving transportation vehicles, such as a roadway or rail vehicle, the initial steps by the vehicle operator to stop in as remote a location as possible can have significant impact on mitigating the ultimate consequences of the event. This initial first step of placement may or may not have limited options, and it involves vehicle operators and others prior to the arrival of the emergency first responders.

Emergency incidents involving motor vehicles with entrapment, with fire or the potential for fire, present an appreciable challenge for emergency responders. These incidents are a real possibility for any fire department in any jurisdiction. The general diversity of motor vehicle designs further increases the challenges faced by today's emergency response community, and they are looking for ways to have accurate, consistent and timely vehicle information readily available during an emergency (i.e. for extrication work, etc).

For fixed site applications like a refueling station or stationary fuel cell power supply, the ability to isolate the incident depends on the foresight of the code enforcement and permitting approval process. In these cases this highlights the fundamental importance of the siting component of the permitting process.

Safe distances between possible adjacent exposures need to be fully anticipated, not only for an incident where the hydrogen is the source of the fire but also from fires advancing from exposures towards the hydrogen installation. For example, a stationary fuel cell emergency power supply for a telecommunication cell tower is often at a remote location away from other buildings, but precautions still need to be considered for the very real probability of an advancing wildfire that could threaten the installation.

Depending on the extent of the incident, responding to and properly handling a hazardous materials incident will involve multiple organizations and agencies over the time frame of its occurrence. The complexities of the event often require specialized organizations and

individuals from other than the local level (i.e. regional, county, state, or federal support). An important concept used by the fire service response is mutual aid. This occurs when a neighboring jurisdiction provides support and resources for a large scale event that exceeds the available resources of the host jurisdiction. Mutual aid is not a new concept and has existed for centuries.

Figure 1-30: Typical Approaches for Emergency Pre-Planning

Pre-planning prior to an anticipated event can be accomplished through an Emergency Action Plan, Incident Response Plan, or Site Safety & Control Plan, as illustrated in Figure 1-30.[162] From the standpoint of those in charge of a particular event, important steps that would generally be considered for the approach taken are summarized in Table 1-20.[163]

Table 1-20: Basic Steps for Handling a Hazardous Materials Event [164]

1) Analyzing the incident.
    a. Collecting and interpreting hazard and response information.
    b. Estimating potential outcomes.
2) Planning the response.
    a. Identifying response objectives.
    b. Identifying potential response options.
    c. Approving the level of personnel protective equipment.
    d. Developing an incident action plan.
3) Implementing the planned response.
    a. Implementing an incident command system.
    b. Directing resources.
    c. Providing a focal point for information exchange with the media and elected officials.
4) Evaluating progress of the incident action plan.
5) Terminating the incident.
    a. Transferring command and control.
    b. Conducting a debriefing.
    c. Conducting a critique.
    d. Reporting and documenting the incident.

Any emergency event may involve rescue, and in addition to the obvious task of stabilizing and transporting any involved victims, emergency response personnel themselves are also at risk. The exposure to dangerous conditions is exacerbated by the inherent risks of hazardous materials, and fire service personnel and other responders need to take special precautionary steps. As shown in Figure 1-31, important basic concepts need to be considered by all involved to assure adequate levels of occupational safety and health, including: incident management, risk evaluation during emergency operations, personnel accountability, rapid intervention methods, rehabilitation, and post-incident analysis.[165]

Figure 1-31: Basic Concepts to Consider for Occupational Safety and Health

When an emergency event occurs, such as a leak from a vessel containing hydrogen, there is precious little time for the emergency response infrastructure to respond and take mitigating action. These events can be very complex, and each is unique with multiple variables the gives each a distinct set of problems that normally require quick action to mitigate the danger.

In previous discussion we have provided a description of emergency first responders and fire service organizations. It's relatively clear that if an adverse event occurs that the local fire department will be the emergency first responders initially on scene. However, how does this operation work for large scale events requiring additional resources? It is not unusual for an event to occur during the course of any particular one year time frame that exceeds the capabilities of what the immediate local jurisdiction has available for resources. During such occurrences, the locally impacted fire service organization will rely on "automatic mutual aid" from their neighboring jurisdictions, to boost provide the necessary staff and equipment to handle a large scale event.

It is a daunting thought to coordinate the response to a large scale disaster, involving staff and equipment from multiple independent jurisdictions (either at the local, state or federal level), and with very little time to coordinate these resources. However, an effective communication system is in place to address these challenges, and this is known as the National Incident Management System (NIMS). The NIMS infrastructure is paralleled by an NFPA document that includes the same information as a model standard, and this is NFPA 1561, Standard on Emergency Services Incident Management System.[166]

NIMS is administered by the U.S. Federal Emergency Management Agency, and it provides a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector. It is intended to facilitate these groups to work seamlessly to prevent, protect against, respond to, recover from, and mitigate the effects of incidents, regardless of cause, size, location, or complexity, in order to reduce the loss of life and property and harm to the environment. The NIMS provides the template for the management of incidents, and it works alongside the National Response Framework which provides the structure and mechanisms for national-level policy for incident management.[167]

For large scale events involving hazardous materials, an important mutual aid resource is often available to the fire service through the "Local Emergency Planning Committee" (LEPC) for that area.[168] The LEPC is required by federal law, and depending on their arrangements they may provide back-up mutual aid resources to a local community for a hazardous materials event. As background, the genesis of the LEPCs can be traced to a string of major federal legislation that occurred between 1970 and 1986 to address the storage and use of hazardous materials affecting health, safety and the environment. This includes the following:[169]

- "*Occupational Safety and Health Act*" of 1970 creating the Occupational Safety and Health Administration (OSHA);
- "*National Environmental Policy Act*" of 1970 that established the Environmental Protection Agency (EPA);
- "*Clean Air Act*" (CAA) of 1970 resulting in a major shift in the federal government's role controlling air pollution;
- "*Toxic Substances Control Act*" (TSCA) of 1976 giving the EPA the ability to track 75,000 chemicals;
- "*Comprehensive Environmental Responsibility, Compensation and Liability Act*" (CERCLA) of 1980 establishing the "Superfund" to tax industry creating a fund for environmental clean-up; and
- "*Emergency Planning and Community Right-to-Know Act*" (EPCRA) of 1986, also known as Title III of the "*Superfund Amendments and Reauthorization Act*" (SARA), which is intended to assist local communities with the protection of public health, safety, and the environment from hazardous chemicals.

More specifically, the LEPCs are the direct result of the last of these federal legislative acts, EPCRA (more commonly referred to as *Title III of Superfund Amendments and Reauthorization Act*). Enacted under 42 U.S.C. §11001 et seq. in 1986, under this law Congress requires each state to appoint a State Emergency Response Commission (SERC). In turn the SERC divides their respective state into Emergency Planning Districts, with an LEPC for each district.[170] In summary, the LEPC is able to coordinate additional resources for a large scale hazardous

materials event that exceeds the resources of a particular local jurisdiction. In recent years, the Department of Homeland Security has been able to coordinate other initiatives that utilize this preexisting infrastructure for certain intra-state and multi-state emergency management operations.

Incident Response Personnel and Organizations

Several sources provide an outline of the basic categories of individuals that respond to a typical hazardous materials incident. In particular, NFPA 472, Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents addresses five basic categories, and these parallel the requirements of OSHA 1910.120 administered by the U.S. Occupational Health & Safety Administration.[171]

The five basic categories of emergency first response professionals that respond to a hazardous materials incident are summarized in Table 1-20 and shown in Figure 1-32. Some of these general categories also have multiple sub-levels to further distinguish the individual operating at a hazmat site. For example, Table 1-21 includes the three sublevel definitions for Private Sector Specialist Employee, ranging from Group A who are not expected to enter the hot/warm zone at an incident, to Groups B and C who have increasingly higher levels of competence and responsibility.[172]

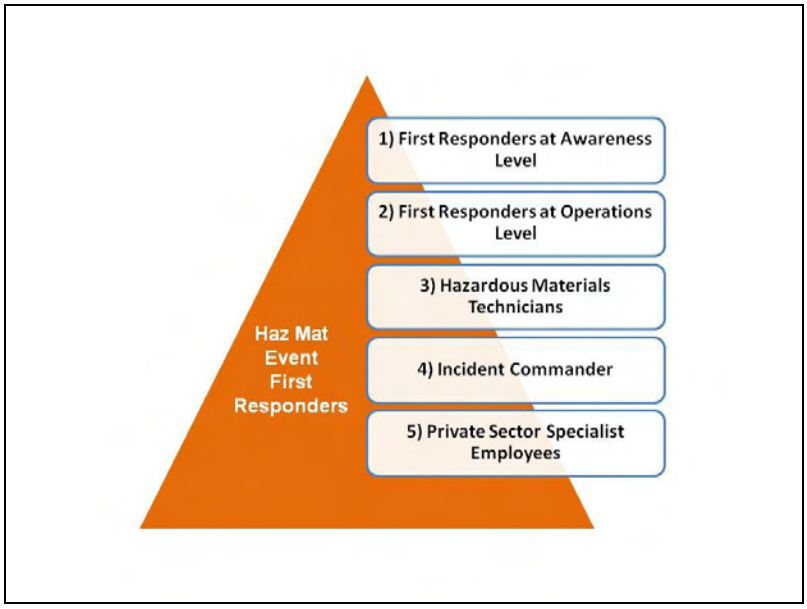

Figure 1-32: Summary of Hazardous Materials Emergency First Responders

The handling of hazardous materials events, whether it involves hydrogen or any other substance, can be complicated. The level of planning involved and the resources needed with these events is extensive, and this is reflected by the relatively sophisticated nature of the backgrounds of the professionals who respond. Further illustrating these complex nature of

the duties facing emergency first responders are the job task requirements for an incident commander.

Table 1-22 provides a summary of the specific job tasks to which an incident commander can be certified. This information is taken from NFPA 1026, *Standard for Incident Management Personnel Professional Qualifications*, and this provides an indication of the complexities of this particular individual's duties and the overall activities that may face the entire emergency first responder community at any given time.[173]

Table 1-21: Basic Categories of Emergency First Responders at Hazardous Materials Events [174]

CATEGORY		DESCRIPTION
1)	First Responders at the Awareness Level	Personnel who, in the course of their normal duties, could encounter an emergency involving hazardous materials/WMD and who are expected to recognize the presence of the hazardous materials/weapons of mass destruction (WMD), protect themselves, call for trained personnel, and secure the scene. (NFPA 472-2008, 3.3.4)
2)	First Responders at the Operations Level	Persons who respond to hazardous materials/WMD incidents for the purpose of implementing or supporting actions to protect nearby persons, the environment, or property from the effects of the release. (NFPA 472-2008, 3.4.4)
3)	Hazardous Materials Technicians	Person who responds to hazardous materials/WMD incidents using a risk-based response process by which they analyze a problem involving hazardous materials/weapons of mass destruction (WMD), select applicable decontamination procedures, and control a release using specialized protective clothing and control equipment. (NFPA 472-2008, 3.3.33)
4)	Incident Commander	The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources. (NFPA 472-2008, 3.3.36)
5)	Private Sector Specialist Employee A	That person who is specifically trained to handle incidents involving chemicals or containers for chemicals used in the organization's area of specialization. (NFPA 472-2008, 3.3.58.1)
	Private Sector Specialist Employee B	That person who, in the course of his or her regular job duties, works with or is trained in the hazards of specific chemicals or containers within the individual's area of specialization. (NFPA 472-2008, 3.3.58.2)
	Private Sector Specialist Employee C	That person who responds to emergencies involving chemicals and/or containers within the organization's area of specialization. (NFPA 472-2008, 3.3.58.3)

Significant resources exist at the state and federal level to assist the emergency first responders at the local level to address issues involving hazardous materials. Some of this is directly developed for emergency first responders, and other information is intended for secondary audiences but is still particularly helpful.

For example, the Federal Motor Carrier Safety Administration under the U.S. Department of Transportation provides regional contacts and support in each state to assist with the permitting and registration of hazardous materials for motor carriers and shippers. The assistance they provide helps to coordinate the complex tangle of interstate shipment of hazardous materials, and this in turn provides convenient summaries of this information for use by others, including the emergency response community.[175]

Table 1-22: Professional Qualification Duties Relating to Incident Management [176]

Incident Commander	Air Support Group Supervisor	Food Unit Leader
Safety Officer	Air Tactical Group Supervisor	Support Branch Director
Public Information Officer	Planning Section Chief	Supply Unit Leader
Liaison Officer	Resource Unit Leader	Facilities Unit Leader
Operations Section Chief	Situation Unit Leader	Ground Support Unit Leader
Staging Area Manager	Documentation Unit Leader	Finance/Admin Section Chief
Operations Branch Director	Demobilization Unit Leader	Compensation/Claims Unit Leader
Operations Div/Group Supervisor	Logistics Section Chief	Cost Unit Leader
Strike Team/Task Force Leader	Service Branch Director	Procurement Unit Leader
Air Operations Branch Director	Communications Unit Leader	Time Unit Leader
	Medical Unit Leader	

Post-Event Issues

Hydrogen is a hazardous material, and for any incident involving hydrogen release, fire, or explosion, the response of the fire department and other emergency first responders will be the same for certain overarching details. In particular, once a situation is brought under control, additional steps are required to secure the scene and close-out the incident.

The most important step is the rehabilitation of the emergency first response personnel who were involved with handling the incidents. A specific focus is provided for rehabilitation both during an incident and after the event. The details of a full rehabilitation program are addressed in detail in document such as NFPA 1584, *Standard on Rehabilitation Process for Members During Emergency Operations and Training Exercise*.[177]

Additional activities may be required depending on the details of the event. If there are questions on the cause and origin, local, state and/or federal fire investigators will be required to document the scene. Additional documentation may be required from the standpoint of updating response operations and training, or for possible damage to the surrounding environment. People may be displaced for a period of time requiring shelter, meals and basic services. Large scale events will also require additional possible follow-up with media contacts and elected officials.

6) PART 1: SUMMARY OBSERVATIONS

This report provides a detailed primer on the structure of the Fire Service in the United States, both from the fire prevention and emergency response perspectives. Various details are provided to describe certain important characteristics such as key organizations, typical responsibilities, approaches used to handle fire safety concerns, and other pertinent details.

The goal of this effort is to improve the transfer of hydrogen safety information to and from the fire service. The fire service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. This effort provides an overview of the U.S. fire service and information as to how to communicate with the U.S. fire service in key jurisdictions.

The result is a roadmap overview of the U.S. Fire Service, as well as information for facilitating communications with the U.S. Fire Service in key jurisdictions. The infrastructure for decision making and for communication varies from jurisdiction to jurisdiction (state, city and region across the country) and by multiple other factors. Working with the multiple jurisdictions is important to help implement the on-going programs required to enable more widespread hydrogen usage.

The following are specific observations that can be found throughout this report and summarized here for convenience:

Hydrogen Features and Physical Characteristics

- Hydrogen has been widely used in industrial, medical and certain other areas for decades.
- Widespread use of hydrogen by the broad consumer market (e.g. automobiles) at this time is minimal and is lacking the necessary supporting infrastructure.
- The future use of hydrogen is expected to increase based on certain features (e.g. minimal environmental impact) that make it an attractive source of alternative energy.
- Some hazard concerns of hydrogen are more hazardous (e.g. wide flammability range and ease of ignition) and some are less hazardous (e.g. buoyancy in air and diffusion rate) when compared to other conventional fuels.
- Hydrogen use as a fuel is operationally comparable to other conventional fuels (e.g. CNG).
- Hydrogen safety concerns important to emergency first responders (e.g. storage quantities) are generally similar to certain other conventional fuels (e.g. CNG).
- Useful web-based resources addressing hydrogen safety are available through the U.S. Department of Energy and other resources.

Applications Using Hydrogen

- A jurisdiction or community is today more likely to have an application involving a stationary hydrogen fuel cell emergency power supply than a hydrogen refueling station for vehicles.
- Hydrogen powered stationary fuel cell emergency power supplies are likely to have lower storage quantities than a hydrogen refueling station.
- The storage and dispensing safety concerns of a hydrogen refueling station are similar and consistent with other widely used and well-established conventional fuels (e.g. petroleum, CNG, etc).
- Remotely located stationary fuel cell power supplies using hydrogen are generally of less concern than stationary fuel cell power supplies located adjacent to existing occupancies (e.g. hospital, casino, etc) that present exposure and other risk concerns.
- Minimizing the amount of hydrogen in a stationary fuel cell power supply significantly minimizes the hazard (for example using piped natural gas to generate re-formed hydrogen used directly by fuel cells).
- On-site hydrogen is technologically feasible and allows the realistic option of private hydrogen fuel production for installations such as motor vehicle refueling stations and private residential occupancies.

U.S. Fire Service Overview

- The fire service is one of three key public service groups providing emergency first response service for the safety infrastructure, along with emergency medical services and law enforcement.
- A majority of municipal U.S. fire departments support both fire service and emergency medical service (EMS).
- Approximately 1.1 million fire fighters provide fire services in the U.S., with approximately three fourths of these as volunteer fire fighters and one fourth as career fire fighters.
- The U.S. fire service is organizationally de-centralized and is comprised of approximately 30,000 independent fire departments.
- Multiple regional and national resources support the U.S. fire service and assist with establishing consistency for activities such as operations, prevention, and training.

Permitting Infrastructure

- Police power used to enforce building safety is provided to State governments based on the Tenth Amendment of the U.S. Constitution.
- “Home Rule” describes how a State has delegated its police powers to its local jurisdictions.
- The appropriate jurisdictional official should be involved in the planning, implementation and construction process as early as possible.

- The permitting process in each state is unique and can vary widely, and similarly can have further differences at the local level.
- The Authority Having Jurisdiction may include officials with statutory authority (e.g. Fire Marshal) and with non-statutory authority (e.g. insurance representative).
- The permitting process frequently involves the local fire official, the local building official, and/or state level officials.
- Who owns the property or facility directly impacts the permitting process (e.g. federal, state, tribal and other special owners who are exempt from local requirements applied to the public).

Fire Service Incident Response

- An event involving hydrogen is typically considered a hazardous materials event
- Fire service incident response first uses immediately available local resources, and then if necessary uses regional, state, or national resources.
- Trained fire department response to hazardous materials events is generally consistent and is based on regionally and nationally available resources (e.g. NFPA standards, Local Emergency Planning Committee, National Incident Management System, etc).
- Motor vehicles are an appreciable challenge for emergency responders based on the diversity of vehicle designs, vehicle entrapment requiring rescue, and the possibility of an emergency in any jurisdiction.

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REACHING THE U.S. FIRE SERVICE WITH HYDROGEN SAFETY INFORMATION: A ROADMAP

PERMITTING ROADMAP

AND

INCIDENT RESPONSE PROTOCOLS

Part 2 of 3

A Report for:

National Renewable Energy Laboratory

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1) PART 2: INTRODUCTION AND BACKGROUND

The U.S. Department of Energy (DOE) is developing a comprehensive suite of information related to safety in the infrastructure supporting hydrogen energy sources for commercial implementation. The U.S. fire service is an important audience for this information, both as it relates to safety considerations in design and permitting of constructed facilities, and safety considerations related to incident response.

The goal of this project is to improve the transfer of hydrogen safety information to the fire service. The fire service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. This effort will provide an overview of the U.S. fire service and information as to how to communicate with the U.S. fire service in key jurisdictions.

This effort intends to provide a roadmap overview of the U.S. Fire Service, as well as information for facilitating communications with the U.S. Fire Service in key jurisdictions. The infrastructure for decision making and for communication varies from jurisdiction to jurisdiction (state, county, city and region across the country) and by multiple other factors. Working with the multiple jurisdictions is important to help implement the on-going programs required to enable more widespread hydrogen usage.

Three specific tasks comprise the main deliverable of this overall project report, all with a focus on hydrogen-based applications including but not limited to the direct commercial implementation of hydrogen refueling stations and hydrogen back up power installations for telecommunications. The first task (Part 1), involves developing a detailed primer that provides an overview of the Fire Service in the United States. The second task (this section, i.e. Part 2) is to generate permitting roadmaps and incident response protocols, supplemented with examples provided by six case study jurisdictions. The third task (Part 3) is to summarize first responder preferred training needs for applications involving hydrogen-based applications (e.g. road vehicles, rail vehicles, industrial lift trucks, fixed sites, etc).

Specifically, report Part 2 illustrates the common features and diverse nature of both the permitting infrastructure and the protocols used for incident response. Six specific jurisdictions in the United States are reviewed in detail to exemplify the characteristics they have in common as well as certain details which make them unique. This exercise is primarily based on the hypothetical implementation of a commercial hydrogen refueling station and hydrogen back up power installations for a telecommunication cell phone tower.

2) PERMITTING PROCESS FUNDAMENTALS

The detailed information provided for the six case study jurisdictions included in this report are useful to exemplify the functioning of the permitting official's infrastructure. To assist with this review, the information in this section provides basic information on common characteristics inherent to all jurisdictions within the safety infrastructure.

Enforcement Techniques

The fire service in the United States uses various proactive methods to prevent unwanted fires. This includes code enforcement, plan review, inspection, public fire safety education, and fire investigation.[1]

The issuance of permits by the enforcement official is a critical step in the enforcement and application of the safety code requirements of that jurisdiction.[2] This provides the authority having jurisdiction with a direct means for controlling the construction process and on-going safety of the building. The permitting process utilizes plans review, inspection, and enforcement to provide the legal means of identifying and correcting deficiencies from unwanted fire threats to life and property. This involves the issuance of official documents by the applicable fire prevention or safety organization.

These documents are generally referred to as permits but also as licenses or certificates, and are issued in accordance with applicable codes used by fire and other officials to mitigate fire hazards, maintain fire protection systems, ensure safety at special events, and other fire-prevention-related activities. The process allows cross-checking with other safety departments engaged in similar safety reviews such as building, zoning, public health, etc...

Fire Service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. The infrastructure for decision making and for communication varies across the country from jurisdiction to jurisdiction (state, county, city and region) and by multiple other factors.

Most fire service organizations include a component that addresses prevention. This fire prevention component includes any fire service activity whose purpose is to decrease the occurrence and severity of an unwanted fire. This includes inspection of existing facilities, review of plans for new construction, public fire safety education, and post-fire investigations.[3]

A key mechanism used by officials in handling fire prevention duties to assure that a property meets a pre-determined minimum level of safety, is through a permit, inspection and approval process. Permitting allows the appropriate jurisdictional official to assure the level of safety collectively deemed appropriate for the community has been achieved. It provides a

mechanism for the designated safety official(s) for that jurisdiction to uniformly and consistently maintain oversight of the applicable occupancies within his or her jurisdiction. It is important that the appropriate jurisdictional official be involved in the planning, implementation and construction process as early as possible.

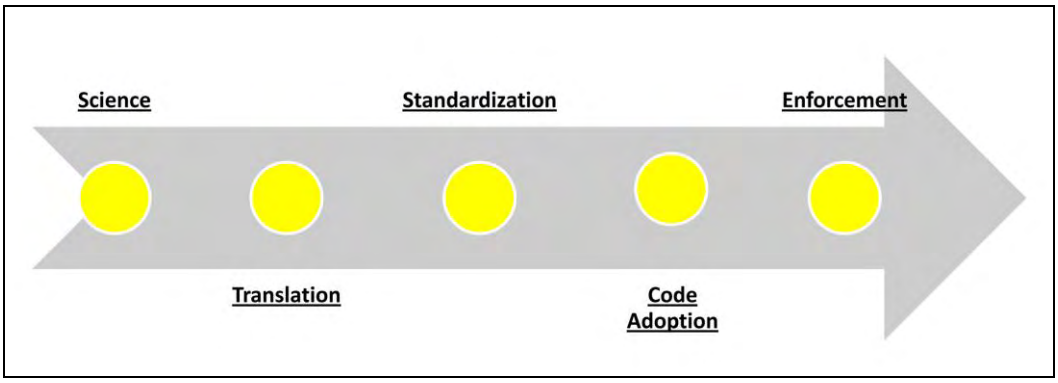

Figure 2-1: Safety Infrastructure Spectrum

Safety requirements intended for the general population require enforcement if they are to be effective. Figure 2-1 shows the key parts of the safety infrastructure spectrum, and illustrates the role of enforcement. At the beginning of this spectrum is the fundamental and applied research that establishes the necessary baseline science on the topic. An example is the multiple research studies addressing the storage, production, handling and use of hydrogen. This is followed by major steps involving translation, standardization and code adoption. Ultimately, the critical information is distilled and provided so that it can then be enforced by the appropriate permitting officials.

The Authority Having Jurisdiction (AHJ) for any particular installation can vary widely depending on multiple factors.[4] Determining the AHJ for any particular facility is not only dependent on its geographic location, but also on a range of other factors such as the type of installation, hazardous materials that will be handled, and the property owners (public, federal government, state government, etc).

The AHJ is most commonly recognized as a government enforcer, and in the United States a typical permitting process will likely require at least one or some combination of the following: local fire official, local building official, and/or a safety official at the state level. In addition, the permitting effort may involve a range of other agencies of groups, such as: planning & zoning board, public utility committee, environmental protection or conservation commission, hazardous materials review committee, historic preservation foundation, or other groups with narrowly defined areas of responsibilities.

The local building official is typically a key part of the permitting process for a new building or facility, and they operate independently from the fire service through other local government agencies. They are a particularly important oversight body for new construction and provide

safety oversight similar to the local fire official. Often the local building official will focus on safety and non-safety issues (e.g. environmental impact, community aesthetics, energy conservation, etc) with a focus on approval to build, while the fire official will focus on safety and emergency response with a focus more on the ability to operate. However, symbolic of the occasional overlapping enforcement duties of fire officials and building officials, the two widely used model fire codes in the United States both address new construction in addition to existing installations.

Applicable Model Codes

In the United States almost all states, counties, cities and towns that have adopted construction codes enact and enforce them under their police powers to promote the health, safety and general welfare of its citizens. The application of Building Code and Fire Code normally distinguishes between new construction and existing buildings. Likewise, most codes normally include an appeal process to allow for resolution of code disputes.

Specifically, these powers include placing restrictions on building construction to assure minimum levels of health, safety and welfare. These are accomplished through local legislative means by adopting zoning laws, height and area restrictions, municipal ordinances, and smart growth laws.[5] Subsequently each state has developed its own unique state building and fire codes, and the safety infrastructure (and associated de-centralized permitting processes) rather than one standardized set nationwide.

Most states also have a State Fire Code, which is a critical companion document alongside the Building Code, and has a particular focus on protecting the public's safety and health. The Fire Code is a key tool used by fire inspectors for the on-going enforcement of reasonable levels of fire safety throughout the lifespan of a building.[6] Some states permit each community to adopt its own fire and building codes in lieu of a state code; this leaves some communities without any fire or building code where no state code exists.

A code is a law or regulation that sets forth minimum requirements. Specifically, a Building Code is a law or regulation that sets forth minimum requirements for the design and construction of buildings and structures, and where they are required (i.e. scoping). In similar fashion, other types of codes address the specific topics indicated by their title (i.e., electrical, mechanical, plumbing, etc).[7]

A standard typically provides specific technical requirements for achieving the desired result, i.e., indicating "how" something must be done in terms of an installation or process. While codes address broad overarching topics, standards provide significant technical detail on a specific subject, with the necessary precision to facilitate the applicable design or installation.[8] Because of their broad application codes are generally adopted into law (e.g. State Building Code), with or without specific amendments, and they in turn provide mandatory references to

many hundreds of standards that likewise become part of the legislative requirements by reference.

The codes and standards that are applied and enforced by the AHJ in any particular jurisdiction are adopted into law by the respective legislative body for that jurisdiction. The respective legislative body also specifies which entity or individual is the AHJ. The general approach taken by those authorized to establish the minimum code requirements in that jurisdiction is to adopt an applicable model code or standard, with amendments where necessary and appropriate. Alternatively, a few jurisdictions write their own codes at the state, county or local level, although they typically start with one or more of the national model codes as a starting point. Local ordinances or regulations that sometimes further modify the adopted codes and standards do so by adding detail or making them more stringent.

The Fire Code is a key document providing guidance for the fire service in the permitting process. While the Fire Code will vary from jurisdiction to jurisdiction, most states have adopted one of the two available model fire codes, usually with amendments. These two model documents are the NFPA 1, *Fire Code*, and the IFC, *International Fire Code*.[9, 10]

The degree of amendments at the state level can vary significantly, and further, certain states allow local municipalities (sometimes over a certain population) to adopt an alternative or their own code from the state code. In summary, the Fire Code used locally in a specific jurisdiction cannot be automatically assumed to be the same as the code used by the host state. Nevertheless, the two model Fire Codes provide a useful benchmark of the nationally formulated perspective on an applicable technical subject.

One section in each of the model Fire Codes of particular interest are the requirements on hazardous materials, and specifically, the minimum amount of a hazardous material like hydrogen that requires a fire department permit. Table 2-1 summarizes the minimum threshold quantities for hydrogen which if exceeded will require a fire department permit. These threshold values have evolved through multiple model code documents over the last several decades, and today they provide the primary basis for the permitting of hydrogen found within the United States.[11]

Table 2-1: Minimum Hydrogen Quantities Requiring a Permit[12, 13]

	NFPA 1, Fire Code	IFC, International Fire Code
Flammable Compressed Gas	200 ft3 (5.66 m3) at Normal Temperature & Pressure *(Table 1.12.7 (b), 2009 edition)*	200 ft3 (5.66 m3) at Normal Temperature & Pressure *(Table 105.6.8, 2006 edition)*
Flammable Cryogenic Liquid - Inside Building	Over 1 gallon (3.8 Liters) *Table 1.12.7 (c), 2009 edition)*	Over 1 gallon (3.8 Liters) *(Table 105.6.10, 2006 edition)*
Flammable Cryogenic Liquid - Outside Building	60 gallons (227.1 Liters) *Table 1.12.7 (c), 2009 edition)*	60 gallons (227.1 Liters) *(Table 105.6.10, 2006 edition)*

3) REVIEW OF PERMITTING CASE STUDIES

Despite certain common characteristics, the permitting process used for new construction throughout the United States varies from jurisdiction to jurisdiction (state, city and region). It is typically handled through statutory authority by state or local Authorities Having Jurisdiction (AHJs). The intent of this section is to review the permitting process in further detail, with the assistance of details from six case study jurisdictions that typify the diversity of the permitting process.

Background and Overview

A review of the permitting process in the United States for new construction as well as on-going operation of existing facilities reveals on one level certain common themes and similarities, and at the same time on another level demonstrates the significant diversity and the uniqueness of each jurisdiction.

To assist in this review six specific case study jurisdictions have been examined in further detail to provide useful illustration of certain concepts, commonalities, and distinctive features. Despite the differences, there are certain consistent themes found in most jurisdictions. For example, it would be unusual to not have some level of involvement from the local fire service for applications involving hazardous materials such as hydrogen. This is rooted in their needed involvement if an emergency incident were to occur. Likewise, another example is the involvement of the local building department and/or local zoning board.

In contrast to the commonalities and similar concepts, the diversity of the each jurisdiction across the United States is equally noteworthy. This diversity is dependent on multiple factors. Most obvious is the geographic locations of the jurisdiction which take into account the laws and regulations of that particular jurisdiction, and the available resources available to respond to an emergency event. Other important factors likewise affect this diversity, such as the type and purpose of new facility being considered (e.g. refueling station versus stationary fuel cell), details of the hazardous materials involved (e.g. quantities and types of flammable fuels), possible adjacent exposures (e.g. remote site versus high density urban area), the facility owner/user (e.g. exempt entities like federal or tribal governments), and other factors.

The six jurisdictions selected for this exercise have been chosen with consideration for geographic diversity, size of community, likelihood of future applications involving hydrogen, and various other factors to help personify the broad spectrum of the permitting infrastructure. These jurisdictions are not intended to provide any statistical summary of certain permitting details, nor are they being compared in any sense to provide an assessment of the pros and cons of any particular process. There is no right or wrong being considered with this review, but instead details of the various approaches are provided to help illustrate the overall

permitting official's infrastructure. The intent is to provide useful information for anyone considering the installation of new hydrogen refueling stations, facilities with stationary hydrogen fuel cell power supply, or any other applicable application of interest.

It is noted that any detailed information provided for a particular jurisdiction is subject to continual update. Thus detailed jurisdictional information should only be considered in the context of providing a useful example. The six case study jurisdictions are shown in Figure 2-2 and are:

- Los Angeles, California
- Jefferson County, Colorado
- New York City, New York
- Aiken, South Carolina
- Houston, Texas
- Dane County, Wisconsin

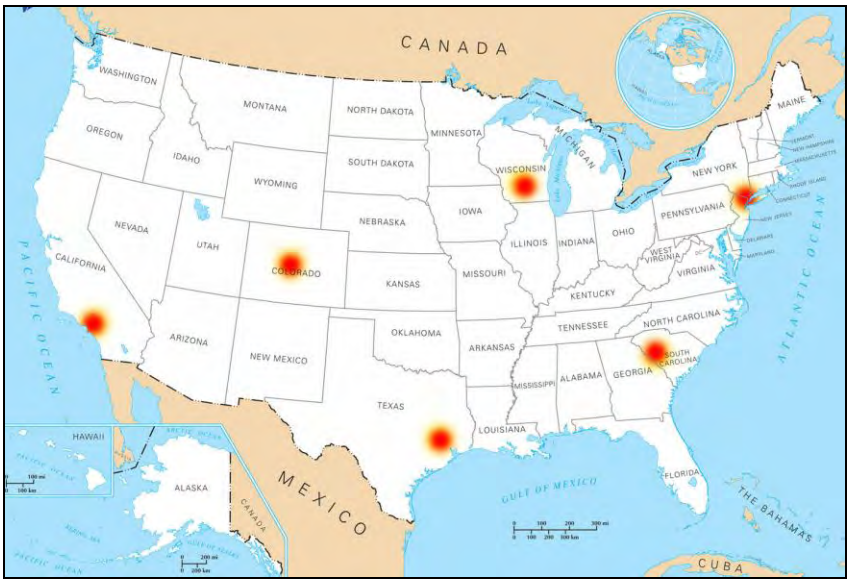

Figure 2-2: Location in the United States of Case Study Jurisdictions[14]

Two hypothetical construction scenarios are used in this review exercise to enable a more detailed analysis of the permitting process. These involve two different focus applications, both of which involve the use of hydrogen. These are:

1) Commercial hydrogen refueling station; and
2) Hydrogen fuel cell emergency power supply for a telecommunication cell phone tower.

While considering these two focus applications, other applications using hydrogen (e.g. industrial processes) are not excluded when there is a relationship. For example, many jurisdictions are already familiar with the hydrogen storage safety concerns based on other uses in their communities such as industrial processes or medical facilities. Thus a particular jurisdiction may already have experience with the permitting approval of other similar applications using hydrogen.

Likewise, certain other new or existing applications may be the stimulus for installations using hydrogen in addition to refueling stations or hydrogen powered fuel cells. For example, there is an increasing trend for the use of hydrogen fuel for indoor industrial lift trucks (i.e. forklifts) because of no adverse indoor exhaust byproducts.[15] Specifically, some warehouse facilities have hundreds of industrial lift trucks requiring appreciable refueling and dispensing operations, and these private dispensing facilities have hazard characteristics and safety concerns similar to the focus application of a commercial hydrogen refueling station. This example also distinguishes the importance of whether or not the refueling station will be private, private with controlled public access, or have open public access similar to today's conventional petroleum refueling station.

Approaching the Permitting Process

Certain fundamental concepts are involved with the installation of any new building, structure or facility. While the specific characteristics of a new installation obviously vary depending on key factors such as type of installation, geographic location, property owner, etc., some common aspects are useful and provide helpful clarification of the overall permitting process. While these concepts are not necessarily universal, they can be observed in many jurisdictions.

Every new installation is unique, but generally new installations that are similar to existing installations will face less approval challenges from the safety infrastructure. Permitting officials welcome designs that are similar to approved existing installations. A simplification of the fundamental steps involved with the basic approach to a new building, structure or facility is illustrated in Figure 2-3.[16]

This is simplified as three basic steps based on the manner that the issues present themselves. However, these are normally not independent steps and they generally do not proceed in consecutive order. Instead, these steps usually occur with overlap, and any particular AHJ may be involved only once or possibly multiple times.

Collectively, the team attempting to move the project forward will include, for example, the owner, design professional, and builder. As they do so, approvals will be required at various steps in the process from the applicable safety officials (e.g. fire marshal, building official, etc) and other AHJs (e.g. environmental board, historic commission, etc).[17]

The initial considerations of any project focus on moving the new installation from general concept to a level of specifics that will allow sufficient preliminary review prior to commitment of further resources.[18] For example, preliminary details for a hydrogen refueling station would likely include the proposed location, basic storage quantities of flammable fuels, fuel dispensing methods, and similar other details that will be required to facilitate discussions involving site selection, community buy-in, and zoning review. Further, the refinement of these basic project

considerations will facilitate clarification of the applicable code and permitting requirements and identify the applicable AHJs.

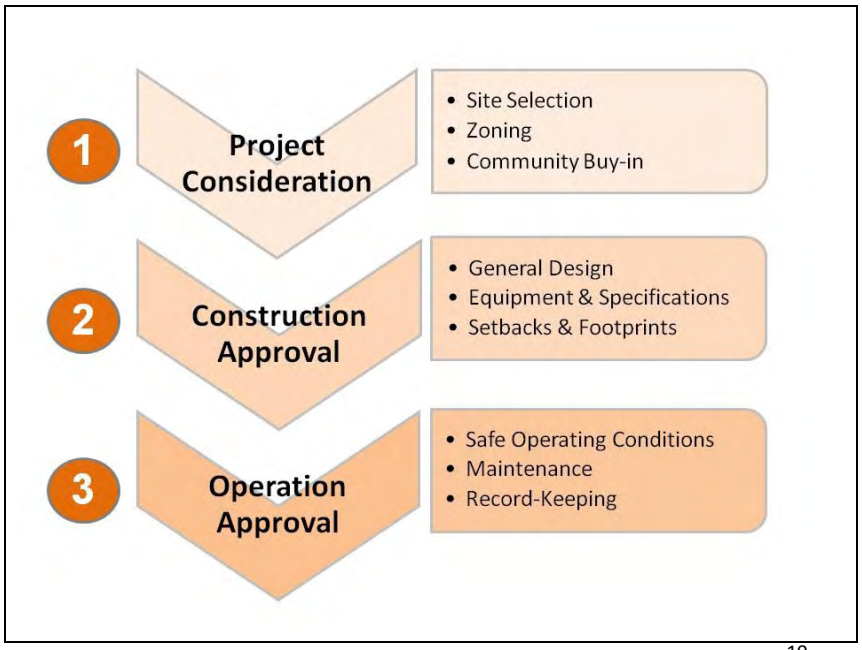

Figure 2-3: Fundamental Steps of the Permitting Process[19]

An example of the non-exclusivity and possible overlap of the steps in Figure 2-3 is exemplified by the role of local Fire Marshal and the local Building Official. Often they serve as the primary simultaneous gateway into the permitting and approval process. Both are normally key players throughout all three fundamental steps, and both generally have veto authority on a project such that it cannot proceed without their separate approvals.

Variations in the steps of the permitting process between jurisdictions occur partly because of the relatively broad spectrum of responsibilities assigned to the local Fire Marshal and local Building Official. Their overall focus on safety can have multiple common points of overlap, although in general the local Fire Marshal often has a higher level of focus on operational concerns based on the local fire code, and the local Building Official often has a higher degree of focus on new construction based on the local building code (and other related codes). Adding to this mix is the local zoning activity, and a separate zoning board/commission may exist or this function may be fully incorporated along with the role of either the local fire marshal or building official.

Clarifying Jurisdictional Authority

Establishing the extent of the jurisdictional authority for a particular installation is dependent on multiple factors. However, in particular three influencing factors are worthy of further discussion and are summarized in Figure 2-4. These factors should be clarified prior to applying

for permits for the installation of a typical installation using hydrogen of other potentially hazardous fuel.

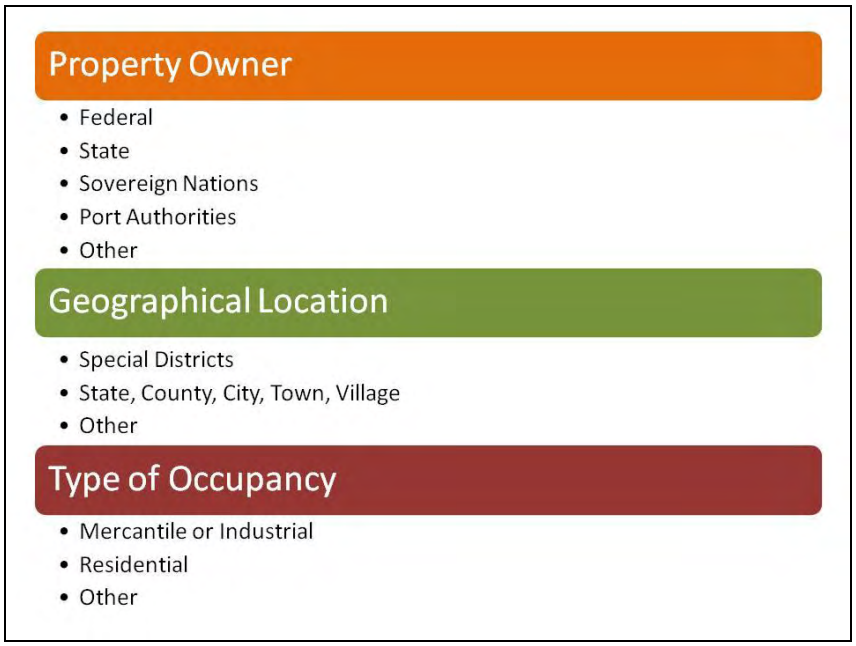

Figure 2-4: Influencing Factors in Determining Jurisdictional Authority

Jurisdictional Authority Based on Property Owner

The permitting and approval processes administered by the frontline safety professionals like the local Fire Marshal and the local Building Official address most of the properties in their jurisdiction, but not all. Interestingly, some installations are exempt based on the property owner, who are their own AHJ and follow their own rules and requirements.

The most obvious of these cases are installations owned and operated by the Federal government. Some of these applications are relatively small and occupy a single building, while others can be very large such as a military base. An interesting example that appears in most communities is the U.S. Postal Service.

Like other federal government entities, the U.S. Postal Service reports through their own internal regulatory approval and permitting process, completely separate and independent from the process used by the local community in which they reside. It is not unusual for them to inform the local fire department of their construction activities, but they do so as a courtesy without obligation, recognizing that any emergency incident may require the services of the local fire service. Some of these localized federal installations are potentially good candidates for hydrogen technologies, such as private fuel storage and dispensing for a delivery fleet used by the local postal service.

In addition to federal government installations that may exist in pocketed locations throughout the local community, some federal government installations are very large in comparison to

their neighboring municipalities. Not only do these facilities often have special hazards, such as military ordinances at a Department of Defense facility, but they also often have special security restrictions that may restrict immediate access by outside emergency responders. A specific example is the Savannah River Site operated by the U.S. Department of Energy, which is partially in Aiken County, South Carolina, and geographically near the City of Aiken. This extensive facility covers 310 square miles with its own well-equipped and highly-trained fire department able to support fire service mutual aid similar to active municipal fire department in the region.[20]

Similar to federal installations being exempt from local requirements are the properties that belong to the State. Again, some of these State government properties can be small and localized, and some can be quite large with extensive campuses. One common example of a large state owned and operated campus-facility is a typical state university, which interestingly are also good candidates for research and prototype installations using hydrogen technology.

In these cases, the permitting and approval process will take place through the appropriate state agencies, and will normally involve the State Fire Marshal's office among others. However, like federal facilities, the local fire and building officials may or may not be kept informed of their activities. In some states the oversight for state properties has been intentionally delegated to the local code officials, and in these cases the state properties are handled similarly to all other installations within their jurisdiction.

While the exemption of local authority over state property is consistent from state to state, the extent of what is considered applicable state property can vary. For example most states define this as property owned by the state, but some also apply their authority and pre-empt local authority beyond the concept of ownership. A specific example is the authority of the Office of the State Fire Marshal in California, which has authority over any state property that is not only owned by the state, but also if it is operated by the state or leased by the state. This can become complicated in situations such as a leased floor of a high-rise building, since state requirements would be applied for that floor of the building, and would include the means of egress components that serve that floor.

Another variation from the authority of local permitting officials is installations that belong to other sovereign nations other than the United States of America. Most notably this includes the Native American Sovereign Nations. Generally these are clearly defined jurisdictions within a State or a County, such as within a county like Jefferson County Colorado. It is less likely for a Native American Sovereign Nation to be included within the boundaries of an incorporated city, town or village. However, different sovereign nation territory may exist such as the embassy of a foreign government. An interesting variation of this is the United Nations in New York City. They operate independent of any local, state, or federal oversight and have their own rules and regulations. But like federal and state properties, they tend to keep the local fire service informed as a courtesy since they depend on them for incident response.

Yet another variation of local requirements are the properties within the domain of pre-designated port authorities. These port authorities may or may not operate independently of the local and/or state permitting officials. For example, the *Port of Los Angeles* functions as a department within the city of Los Angeles government, and the function like any other city department. Thus their permitting process is likewise similar to that which would be followed for any other city installation.[21]

In contrast, *The Port Authority of New York & New Jersey* (PANYNJ) has property in New York City (e.g. World Trade Tower complex) but is independent from the city's permitting and safety-oversight. PANYNJ operates in multiple States and has its own code requirements and enforcement as if it were its own state.[22] An additional example of an independent port authority is *The Port of Houston Authority* which operates in the Houston Ship Channel. Although *The Port of Houston Authority* is entirely within the boundaries of the State of Texas, they have property in Houston and multiple other municipalities in the Galveston Bay region.[23]

Jurisdictional Authority Based on Geographic Location

One of the first steps in determining who to approach for a new building or structure is to clarify the applicable jurisdiction responsible for the specific geographic location. In most cases this can be easily determined based on the clearly defined boundaries of a particular municipality. However, for some cases this is not necessarily straight-forward and may require additional clarification.

For example, in Jefferson County and elsewhere in Colorado, independent Fire Protection Districts normally provide fire protection services. These do not usually follow political boundaries, and identifying the Fire Marshal associated with the local fire department requires identifying the applicable fire protection district. As a specific example, the City of Lakewood is protected by the West Metro Fire Protection District, which covers several other communities in south-eastern Jefferson County but also in parts of neighboring Douglas County.[24] Figure 2-5 illustrates the protection area for the West Metro Fire Protection District, which typifies a special fire protection district providing fire service resources for multiple communities.

Another example is the jurisdictional boundaries between local jurisdictions in Dane County Wisconsin. Certain portions of the City of Madison metropolitan area have involved the recent annexing of unincorporated areas, including portions of adjacent Madison Township. As a result, the identification of the precise jurisdictional boundary can vary from not only street to street, but even property to property. These outlying parts of the community may or may not be connected (i.e. geographically isolated) with the central portion of their community.

Depending on the precise location in this area, it is sometimes less than immediately obvious who will be the AHJ involved in new construction permitting or other community services. The affected municipalities have negotiated with the City of Madison and created annexing agreements for future annexation of certain towns. In the specific example of the Town of Madison, the remaining portions (not already annexed into the City of Madison) will be fully annexed as of November 2022.[25]

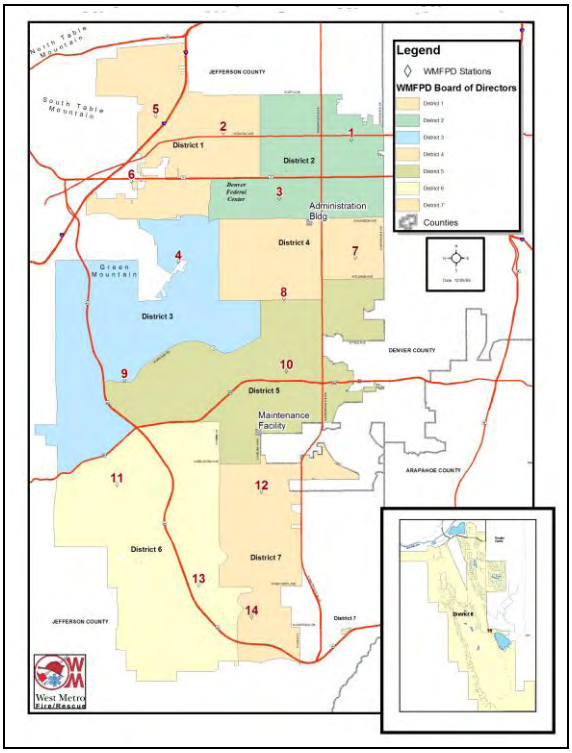

Figure 2-5: Typical Fire Protection District in Colorado[26]

In addition to special fire districts, other types of special districts are found in many areas that might ultimately impact the permitting process. Examples include special watershed or environmental conservation districts in a less populated area, or historic districts in more populated areas. As a more specific example, the City of Los Angeles administers historic overlay zones in pre-assigned areas through the Office of Historic Resources in the Department of City Planning.[27] While facilities using hydrogen would be more likely to be located in commercial and industrial occupancies outside such historic districts, nevertheless this typifies the additional oversight that may occur through a specially zoned district.

Jurisdictional Authority Based on Type of Occupancy

Today's model Building and Fire Codes separate the ultimate use of a building according to a classification system based on type of occupancy. This provides a general categorization of how the facility is expected to ultimately be used at a broad conceptual level. Occupancy is defined as follows:[28]

> *"Occupancy: The purpose for which a building or other structure, or part thereof, is used or intended to be used."*

The categorization of the types of occupancy can vary, but they generally follow those indicated in the model codes. Examples of these are summarized in Table 2-2. Installations using hydrogen, such as a vehicular refueling station or a telecommunication tower with a hydrogen

fuel cell power supply, would most likely be classified as a mercantile or industrial occupancy. These occupancies are defined as follows:[29]

> *"Mercantile Occupancy. An occupancy used for the display and sale of merchandise."*
>
> *"Industrial Occupancy. An occupancy in which products are manufactured or in which processing, assembling, mixing, packaging, finishing, decorating, or repair operations are conducted."*

Table 2-2: Basic Types of Occupancies Used in Building and Fire Codes[30]

Ambulatory Health Care	Detention and Correctional	Mercantile
Assembly	Educational	Residential Board and Care
Business	Health Care	Residential
Day-Care	Industrial	Storage

The application of the proper code requirement is based on type of occupancy, and this will depend on multiple factors, including if the public will or will not have access to the facility. One type of occupancy that may, in certain special situations, be involved with the use of hydrogen is residential.

In many States, the policing powers of the permitting authority are not the same for residential occupancies than they are for all other types of occupancy that can directly impact public safety. This is based on fundamental constitutional rights in the United States that balances the AHJs police power for public safety versus the right of privacy for personal protection.[31] On this basis as well as other factors the code requirements for residential differ from mercantile or industrial.

Installations using hydrogen could be incorporated into any particular occupancy classification if an installation provides refueling operations (both public and private, including residential) or a fuel cell power supply (for backup power). The installation of these systems in all occupancies, including one- and two-family dwellings and other residential occupancies, is regulated with a requirement for on-going inspections. For residential use, the jurisdictional requirements vary and need to be further examined on a case-by-case basis.

Framework of Government Jurisdictions in the United States

Prior to reviewing the details of permitting, regulations and requirements, it is helpful to have a basic understanding of the hierarchy of government jurisdictions in the United States. A basic framework exists that has the federal government at the top, followed by state government, county government, and finally local government involving cities, towns or villages.

The federal government is the top level of government in the United States of America. This was established in 1789 as a federal republic under a strong democratic tradition, and is based on a legal system using English Common Law.[32]

The next level of government after the federal level is the state level, which includes each of the fifty states and the government of the District of Columbia. While the federal government provides certain centralized functions such as foreign relations, currency regulation, and defense, state government has significant autonomy and addresses issues such as industry, business, public utilities, state criminal code, property regulations, etc.

Reporting to the state level are smaller local governing units exist within states, including counties, cities, towns, and villages. These local government entities provide direct services to their residents with services such as fire protection, law enforcement, education, public health, sanitary regulations, and housing. While the incorporated areas of a state generally have a degree of autonomy through the city, town or village to which they belong, it is common for unincorporated areas to be administered by counties, which do so as an agent of the host state.

County governments are the primary subdivision below the state level, and overall there are 3071 counties in the United States.[33] Counties are functioning governmental units and are the primary legal divisions of most states. In Louisiana they are instead known as "parishes" and likewise in Alaska they are referred to as "boroughs". The cities, towns, and villages in each state reside within a particular county, except for Maryland, Missouri, Nevada, and Virginia that have independent cities outside the jurisdiction of any county.

The case study jurisdictions of this report have the following county subdivisions: California-58; Colorado-64; New York-62; South Carolina-46; Texas-254; and Wisconsin-72. Some major cities overlap with multiple counties. For example, Houston Texas overlaps primarily with Harris County, but also to a minor extent several other counties. Another example is New York City, which includes the following five counties in their entirety: Bronx; Kings; Queens; New York; and Richmond.

Incorporated cities and towns generally have a degree of autonomy from the counties they share, and their authority is primarily with the state and independent of most of the county government operations. For example, this is the case with the incorporated cities of: Aiken, South Carolina; Los Angeles California; New York, New York; and Houston, Texas.

The interaction between these levels of government depends of the constitutions and charters of the respective governing bodies. For example, in the United States the Tenth Amendment of the U.S. Constitution provides the States with police powers which they can use to enforce building safety regulations.[34] It does not, however, extend this to counties or local jurisdictions within the states, which instead is done through the respective State constitution, State statute, or home rule charter that describes how the state has delegated its authority. The term "home rule" is used to describe how a state has delegated its authority to the local jurisdiction level.

Home Rule can vary considerably from state to state and is based on state charters, constitutions and other overarching state documents. Specifically, these Home Rule provisions enable the governing authority of incorporated entities within the state (e.g. counties, cities, towns, villages, etc) to establish their own safety provisions such as a Fire Code. The six case study jurisdictions reviewed in this study provide municipal home rule in their state constitution, with the date it was enacted, as follows:[35]

- California (1879), self executing for cities;
- Colorado (1902), self executing for any municipality;
- New York (1923), requires enabling legislation for cities, towns, and villages;
- South Carolina (1975), requires enabling legislation for any municipality;
- Texas (1912), requires enabling legislation for cities over 5000 population; and
- Wisconsin (1924), requires enabling legislation for cities and villages.

As further explanation, the degree of local self determination can only be understood for any given state by closely examining state statutes and constitutional provisions. For example, in Wisconsin incorporated areas include cities and villages through enabling state legislation, and towns and townships identify unincorporated areas that report through their respective counties serving as state agents. Sometimes state statute and administrative codes relegate the decision making of community issues to agencies and boards controlled by state legislatures or special districts. An example is Colorado's extensive use of special districts not only for fire protection but also for community services such as water and other public utilities.

Examples of Permitting Processes, Regulations, and Requirements

While the permitting process and associated regulatory requirements will vary from jurisdiction to jurisdiction and installation to installation, there are commonalties worthy of further discussion. To facilitate a review of these commonalities, six specific jurisdictions are reviewed in further detail with consideration of an installation using hydrogen. These jurisdictions are: Los Angeles, California; Jefferson County, Colorado; New York City, New York; Aiken, South Carolina; Houston, Texas; and Dane County, Wisconsin.

Los Angeles, California

The City of Los Angeles, California is one of the three large metropolitan "large-city" urban areas selected for further review, and it is the western-most jurisdiction in the continental United States. Los Angeles is an incorporated area adjacent to the County of Los Angeles California. Based on U.S. Census Bureau data the 2006 population of Los Angeles City was more than 3.8 million, making it the second most populated city in the United States.[36] Figure 2-6 illustrates the county map for the State of California.

The State Fire Code for California is addressed by the California Code of Regulations Title 24, Part 9. The 2007 edition of the state code is based on the 2006 edition of the International Fire Code with amendments.[37]

In California, the authority to provide local code requirements (i.e. home rule) has existed since 1879 and is self executing for any city. Thus, Fire Code requirements at the state level are only applicable for unincorporated areas and certain applications like state owned facilities, or if the city chooses to defers to the state code. The City of Los Angeles has its own Fire Code referred to as the "Los Angeles Fire Code", and specifically this is Chapter V, Article 7 of the "Los Angeles Municipal Code".[38]

Figure 2-6: County Map of State of California[39]

Regulatory code requirements other than the Fire Code in Los Angeles City, such as the city Building Code, codes for various utilities, and other regulatory requirements are administered by the City of Los Angeles "Department of Building and Safety". This department also has responsibility for zoning and planning issues within the jurisdictional boundary of the city, and thus they are a key group in the overall permitting process.[40] Specific additional reviews by other agencies, such as historic commission, environmental review, and utility board may additionally be required depending on the specifics of the particular installation under consideration.

Los Angeles City already has some limited experience with new facilities using hydrogen both for refueling operations and with stationary power generation. These installations have primarily been at industrial settings.[41] This includes certain hydrogen refueling stations that are private or have limited public access, and would likely be considered a commercial occupancy if public access was less restricted. The City already has commercial locations handling CNG fuels, and at this time the basic similarities between CNG with hydrogen allow it to be viewed positively from the standpoint of the local permitting process.

The State of California has multiple private and public programs supporting the development of technologies using hydrogen, and these are useful resources for property owners, authorities having jurisdiction, and others faced with addressing these types of installations. The "California Hydrogen Highway", for example, provides useful information on the hydrogen related installations within the State either already existing or planned, providing useful case study applications demonstrating local specific permitting processes.[42] As one specific example in the City of Los Angeles, California State University Los Angeles (CSULA) was recently awarded funding to build a new 60 kg/day hydrogen refueling station to operate adjacent to an electric vehicle charging station on the East side of campus.[43]

Other organizations likewise provide useful supporting information promoting proliferation of the facilities handling hydrogen, such as the California Stationary Fuel Cell Collaborative and California Fuel Cell Partnership, as well as various state government programs through agencies such as the California Energy Commission and the Air Resources Board. Some of these organizations operate on the local level and promote general development, such as the "Community Redevelopment Agency" in Los Angeles City.[44]

Jefferson County, Colorado

Jefferson County, Colorado exemplifies a typical County government in a mid-west state. Jefferson County is a mix of both urban and expansive rural areas, and it includes the western suburbs of Denver, the State Capital and largest city in the state. The county population exceeded 533,000 based on 2008 estimates, and the jurisdiction covers approximately 772 square miles.[45] Figure 2-7 illustrates the county map for the State of Colorado.

To provide additional focus on the local level, a specific jurisdiction within the county has been further identified, and this is the City of Lakewood, which based on 2006 data, had a population of just over 140,000.[46] Meanwhile, fire protection services in Colorado often does not follow political boundaries, and this is the case in Jefferson County with the City of Lakewood, which is protected by the West Metro Fire Protection District that protects Lakewood and multiple other communities in the region.

Statewide adoptions in Colorado include the Division of Fire Safety's Fire Suppression Program which has adopted amended versions of the 2006 editions of NFPA 1, *Fire Code*, and the IFC, *International Fire Code*.[47] These statewide adoptions are applicable only for certain applications, such state owned facilities. In Colorado, the authority to provide local code requirements (i.e. home rule) was established in 1902 and is self executing for any municipality. While Jefferson County has adopted various editions (with amendments) of model codes from the International Code Council, they defer the specific Fire Code to the local Fire Districts located throughout the County.[48]

The City of Lakewood, Colorado is located within Jefferson County, and this is used as an example of local community within the County to provide additional focus. For public property within the City of Lakewood, the Lakewood Department of Community Planning & Development applies the local Building Code along with zoning rules, Mechanical Code, and

other applicable regulations. Meanwhile, the responsibility for the Fire Code is handled by the Fire District in that area.[49]

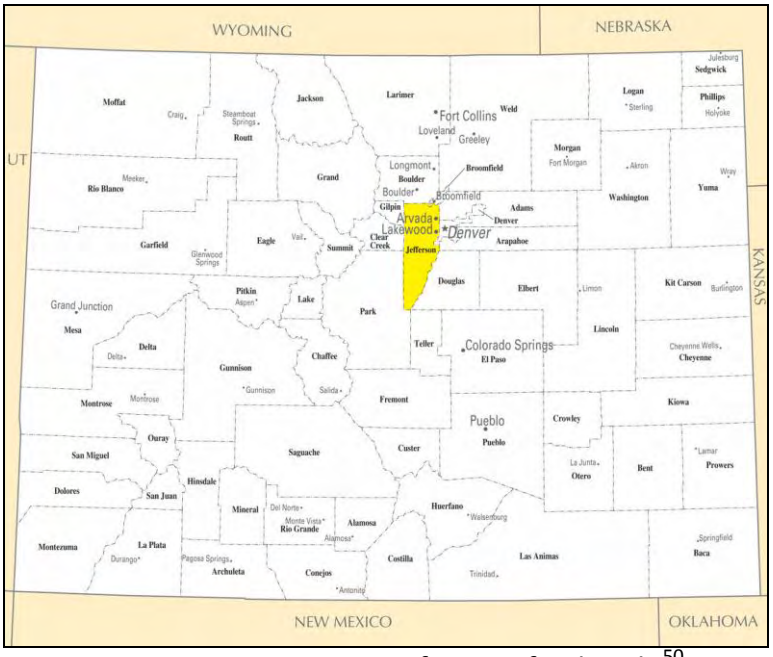

Figure 2-7: County Map of State of Colorado[50]

In Colorado on the local level, independent Fire Protection Districts provide fire protection services. These fire districts do not follow political boundaries and usually cover multiple municipalities and rural areas, and they have the authority to tax the residents in their district for services provided. Specifically, the City of Lakewood is part of the West Metro Fire Protection District. The West Metro Fire Protection District operates 15 fire stations that protect all or portions of the following Colorado communities: Golden; Lakewood; Littleton; Morrison; and Roxborough/Littleton. For fire prevention and fire code permitting, the West Metro Fire Protection District uses the IFC 2006 edition with amendments.[51]

<u>New York City, New York</u>

New York City, New York is the largest city in the United States in terms of population, and one of the most populace in the world. It is the eastern-most jurisdiction in the continental United States included in this review. The population was more than 8.2 million based on 2006 estimates, and it has a population density of more than 26,000 people per square mile.[52] Figure 2-8 illustrates the county map for the State of New York.

New York has a statewide Fire Code, and the 2007 edition of the State Fire Code has its genesis with the 2003 edition of the IFC with amendments.[53] Since 1923, the State of New York has provided the authority for cities, towns, and villages to provide local code requirements (i.e. home rule) through enabling legislation.

This is the case with New York City, which has their own Fire Code based on the 2003 edition of the IFC with amendments. This is administered by FDNY (Fire Department of the City of New York) Bureau of Fire Prevention, and the latest edition was implemented on 1 July 2008. The New York City Fire Code is codified as Title 29 of the Administrative Code of the City of New York.[54]

Figure 2-8: County Map of State of New York[55]

While the Fire Code in New York City is administered and enforced by FDNY, other applicable codes such as the City Building Code are handled by the New York City Department of Buildings. Approximately 950,000 buildings and properties exist within the city, and the Department of Buildings ensures their safe and lawful use by enforcing the City's Building Code, Zoning Resolution, and other applicable laws and regulations.[56]

<u>Aiken, South Carolina</u>

The City of Aiken is located in Aiken County on the Southwest side of South Carolina near the state border with Georgia. Aiken is a smaller sized metropolitan urban area, and geographically representative of a typical mid-Atlantic or Southern municipality. The population of Aiken based on 2006 estimates was just under 29,000 residents in a land area that is only about 16 square miles.[57] Figure 2-9 illustrates the county map for the State of South Carolina.

The State of South Carolina uses the 2006 edition of the IFC, and this is included in Title 23, Chapter 9 of the South Carolina Code of Laws.[58] Home Rule requirements in South Carolina were established in 1975 and can be applied to any municipality through enabling legislation.

The City of Aiken uses the South Carolina State Fire Code, although legislatively it is possible for them to provide their own code. The Aiken Fire Code is administered by the Aiken Department

of Public Safety. In Aiken, this department simultaneously provides fire protection and law enforcement services for the city.

The fire protection provided by the Aiken Department of Public Safety is based on a fire district as agreed to by the city council and the local county council (Aiken County). The fire district loosely follows the City of Aiken political boundary and also includes several additional unincorporated areas of Aiken County. For areas outside the Aiken city limits but still within the fire district, fire protection service are provided based on previously established agreements between the city and the particular property owner.[59]

Local code requirements other than the Fire Code in the City of Aiken, such as the local Building Code, codes for various utilities, and other regulatory requirements are administered by the City of Aiken Building Inspection Services Department. Similarly, zoning and planning issues are administered by the City of Aiken Planning Department.[60] While the City of Aiken does not currently have hydrogen refueling or related installations within city limits, they have familiarity with these type of facilities based on installations nearby within Aiken County, including a new hydrogen refueling station located in the neighboring community of Graniteville.[61]

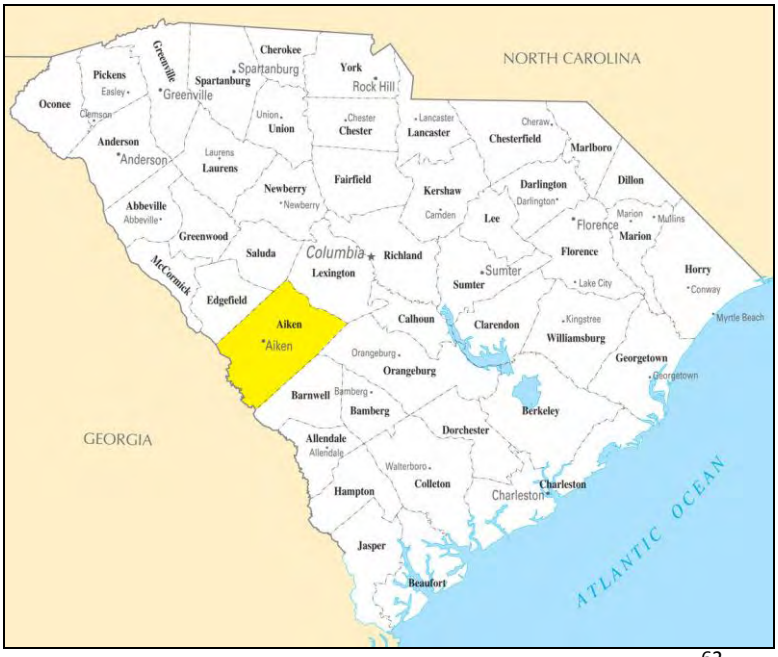

Figure 2-9: County Map of State of South Carolina[62]

South Carolina, like certain other States, has certain resources available from various public and private statewide organizations that can assist with new installations using hydrogen technologies. For example, this includes State government based websites like the "South Carolina Business One Stop".[63] They provide, among other services, a convenient centralized portal into permitting and licensing issues faced by the business community for municipalities located throughout the State.

Additional private resources in South Carolina are also quite useful. An example is the South Carolina Hydrogen and Fuel Cell Alliance operating out of the State capital of Columbia.[64] In particular, this group has been instrumental in facilitating legislation through the South Carolina State Assembly that is currently pending approval.[65] This bill, once approved, will centralize the permitting and approval process through the South Carolina State Fire Marshal's office, and will significantly streamline the installation of new facilities in South Carolina that use hydrogen.

Houston, Texas

Houston, Texas is the fourth most populated city in the United States, and the Southern-most jurisdiction explored in further detail by this study. The population of Houston based on 2006 data was more than 2.1 million residents.[66] Figure 2-10 illustrates the county map for the State of Texas.

Multiple fire protection policies, programs and activities are coordinated at the State level in Texas. While Texas doesn't provide a statewide Fire Code, the state does allow counties the option of adopting NFPA 1, *Fire Code*, and the IFC, *International Fire Code*. Statewide fire protection duties are primarily administered through the State Fire Marshal's Office, which operates as part of the Texas Department of Insurance.[67] The State Fire Marshal's Office uses NFPA 101, Life Safety Code as a central document for basic requirements, and they refer to other documents as needed with the ability to use the latest available codes and standards as guidance documents.

Additionally, certain fire protection concerns and related topics may also involve other state agencies. An example is the Railroad Commission of Texas that provides licensing for various flammable gases like LPG, CNG and LNG, which was established in 1891 and has evolved safety regulations that for these flammable materials.[68] Other State agencies that may potentially have involvement with installations involving hydrogen may include the Texas Department of Agriculture (for weights and measures) and the Texas Commission on Environmental Quality (for fuel storage tanks).

While the State has the authority to pre-empt local authorities on certain fire protection related matters, they generally do not except on a complaint basis. In addition, some fire protection responsibilities are delegated to the 254 counties throughout the state based on certain county qualifications such as overall county population.[69] This includes in some cases the appointment of a County Fire Marshal, and the ability of the county to collect taxes for the fire protection services.[70]

At this time approximately one-fifth of the 254 counties in Texas have their own local Fire Marshal.[71] The fire protection services provided by the County are intended primarily for unincorporated areas and incorporated areas that defer to the resources of the County. Cities over 5,000 in population have home rule status based on enabling legislation in 1912, although enabling legislation is required for this to occur.

The City of Houston has its own Fire Code based on an amended version of the IFC-2000 edition.[72] The Houston Fire Code is administered the Fire Marshal's Office of the Houston Fire Department, and they are responsible for operational permits for installations such as those using hydrogen.

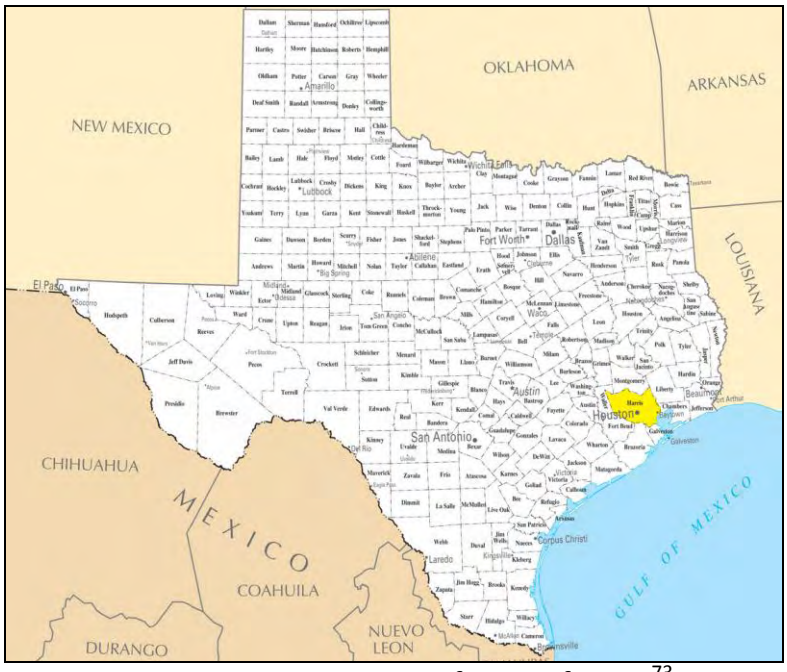

Figure 2-10 County Map of State of Texas[73]

With regard to other applicable laws and regulations for new construction, the Houston Building Code and other pertinent rules are administered by the City of Houston "Department of Public Works and Engineering". Specifically, these are handled by the Code Enforcement Branch of the Office of Planning and Development Services, and they are the primary point of contact for construction permits.[74] This department coordinates closely with other departments as needed on a case-by-case basis, including necessary approvals from the fire department.

One aspect of the Houston permitting process that appears to be somewhat unique among most other jurisdictions is a permitting process absent of a zoning or planning review that frequently occurs under the auspices of the local building department. While certain specific local bylaws and regulations might apply for new construction in certain areas, these are generally applied through the normal permitting review process rather than a separate zoning review process. For example, applications involving hazardous materials may be subject to additional review by the City Planning Division (within the City of Houston Department of Public Works & Engineering), but this is handled on a case by case basis.

<u>Dane County, Wisconsin</u>

Dane County, Wisconsin provides an example of a large rural jurisdiction that includes a mix of rural and urban settings, and is the Northern–most jurisdiction reviewed. Additional focus on

the local level has been provided by focusing on the Town of Madison, which is an unincorporated jurisdiction within the Dane County alongside the City of Madison.

Dane County is located in the South-central portion of the state and has a population of approximately 477,000 based on 2007 estimates.[75] The Town of Madison has approximately 7,000 residents, and is located in central Dane County in the metropolitan area that includes the City of Madison. The population of the City of Madison is approximately 223,000. The state capital of Wisconsin is located in the City of Madison, and it is the second largest city Wisconsin behind Milwaukee. Figure 2-11 illustrates the county map for the State of Wisconsin.

The State of Wisconsin provides a statewide Fire Code based on an amended version of NFPA 1, Uniform Fire Code – 2006 edition.[76] The State Fire Code is used throughout the state unless an alternative is used through enabling legislation. For example, Dane County, the Town of Madison, and much of the state use the State Fire Code, while the City of Madison has processed an exemption that allows them to use their own Fire Code based on IFC-2000 edition.[77]

Constitutional "home rule" authority has existed in Wisconsin since 1924 for cities and villages through enabling legislation. County governments were given limited "home rule" authority in 1985.[78] The State of Wisconsin defines their political subdivisions based on the form of government selected by the residents and approved by the Wisconsin State Legislature, unlike most states that establish geographic boundaries based on area or population. The local units of government in Wisconsin include counties, cities, villages and towns.[79]

Figure 2-11: County Map of State of Wisconsin[80]

The counties in Wisconsin carry out or enforce certain state laws on behalf of the state, and are generally considered the local face of state government. Cities, villages and towns are often referred to as municipalities in Wisconsin law, and these are the governmental units that relate most directly to citizens' everyday lives.[81]

However, at the local level towns are distinctly different from cities and villages. Cities and villages in Wisconsin are incorporated municipalities created at the request of the local inhabitants. Seventy percent of the state's population resides in 190 cities and 402 villages.[82] In contrast, towns are not incorporated municipalities, and this means that they are subject to certain governance from the county in which they reside.

In Wisconsin, the Counties assume responsibility for unincorporated portions of their county, including "towns", and thus supplement the local resources. Consequently, while the Town of Madison provides fire protection review through the Town of Madison Fire Department using the State Fire Code, the Dane County Planning and Development Office has authority for other regulatory and permitting issues like zoning in the Town of Madison and other unincorporated areas of the county.[83]

The local fire department is generally the governmental body enforcing the state or local Fire Code throughout the state, and in rural areas where resources are not available this may be done by the County. Like some other states, Wisconsin has fire districts that may operate over large geographical areas that include multiple cities, villages, and towns.[84] However, these differ from fire districts sometimes found in other states since they are not independent fire protection district with taxing authority, but instead multiple separate municipalities that have contractually unified their fire protection resources.[85]

Additional Topics of Interest to Permitting Officials

There are certain issues relating to new installations using hydrogen that are of special interest to permitting officials. Addressing these issues will better facilitate the design, construction and approval of these new installations.

One concern that was mentioned by multiple permitting officials is the need for listed equipment for an installation using hydrogen. The term listed is defined as follows:[86]

> *"Listed: Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose."*

It is common for an AHJ to require listed equipment for any particular new installation. This provides them with a level of assurance that critical components will perform as designed. For example, in a normal building the doors and doorway assemblies are generally required to be listed for a certain fire and smoke barrier performance, thus providing assurance to the AHJ that the door assembly will function as expected during an emergency situation like a fire.

This AHJ perspective is typical for any new installation involving complex equipment and multiple components. For example, this will assure that the components used for dispensing hydrogen will not become a concern later in the life of the installation due to embrittlement of the metal alloys.

One important resource that AHJs will turn to clarify the listing status of equipment are Nationally Recognized Testing Laboratories (NRTLs). These organizations are published in a list available from the U.S. Occupational Safety and Health Administration within the U.S. Department of Labor. These testing laboratories evaluate and test products, and certify if these products comply with standardized performance tests. They generally provide a summary "list" of acceptable equipment that can be used for a particular installation Table 2-3 summarizes the organizations currently recognized as NRTLS by the U.S. Occupational Safety and Health Administration. Once the applicable equipment and components are listed and approved by the AHJ, subsequent installations using the same equipment can be expedited through the permitting process.

Table 2-3: Organizations Recognized as NRTLs by U.S. OSHA[87]

Canadian Standards Association (CSA) (also known as CSA International)
Communication Certification Laboratory, Inc. (CCL)
Curtis-Straus LLC (CSL)
FM Approvals LLC (FM) (formerly Factory Mutual Research Corporation)
Intertek Testing Services NA, Inc. (ITSNA) (formerly ETL)
MET Laboratories, Inc. (MET)
NSF International (NSF)
National Technical Systems, Inc. (NTS)
SGS U.S. Testing Company, Inc. (SGSUS) (formerly UST-CA)
Southwest Research Institute (SWRI)
TUV America, Inc. (TUVAM)
TUV Product Services GmbH (TUVPSG)
TUV Rheinland of North America, Inc. (TUV)
Underwriters Laboratories Inc. (UL)
Wyle Laboratories, Inc. (WL)

Another issue of concern to AHJs is the method of bulk storage used for the hydrogen. Specifically, bulk storage vessels can be either above ground or underground. Underground bulk storage vessels are permanent fixed installations, but above ground bulk storage has the option to either be a permanent fixed installation or large portable containers. For example, the hydrogen refueling station in Aiken County South Carolina, is a portable compressed gas trailer from a typical tractor-trailer unit. This is brought on site and secured to provide a replenished supply. Once it is expended the trailer is replaced with a fresh supply. This

approach is convenient and utilizes bulk storage vessels that are also serving nearby large warehouses with hydrogen fuel cell powered industrial lift trucks.

Debate exists among permitting officials on the risks associated with fixed above-ground bulk storage of compressed gas, versus above-ground bulk storage of compressed hydrogen using portable trailers. There are pros and cons to each method, and at this time both approaches are recognized and used. For an AHJ with a concern on this topic, each approach should be consider the probabilities of a possible adverse event, and the potential frequency and severity associated with such an event.

Another topic of interest to permitting officials is any required variance process required because the applicable codes for that jurisdiction don't apply. This becomes an issue for any AHJ addressing a new installation for the first time. Until they have established a level of confidence that the installation will not create an undue hazard to the public and emergency responders, the initial installation will be critically reviewed.

Some jurisdictions have flexibility to apply the most applicable codes or standards, including outside model codes and standards. However, in other jurisdictions the specific fire code, building code, and other documents are quite specific with their requirements, and will require use of a variance process for new installations not specifically addressed. Such a variance process can extend the overall permitting processing time by days, weeks or months. For example, depending on the specific installation such a variance process in New York City could take up to 3 months.

Permitting officials, like facility owners and others, will generally welcome efforts that will ultimately streamline their review of multiple similar new installations. In particular, this might involve the use of similar facility designs using previously approved (i.e. listed) equipment, such as similarly designed hydrogen fueling facilities or stationary hydrogen powered fuel cell power supplies. Once initially approved by a permitting official, subsequent installations with similar designs/equipment will likely not require as rigorous a review to address unknown safety-related details. Unique installations unfamiliar to the permitting official are more likely to require special permitting review and require longer processing time.

Another approach for streamlining the process is the centralization of permitting review and approval for certain installations (e.g. facilities using hydrogen fuel) at the regional, county or state level. This, however, needs to be implemented while recognizing that in some areas local jurisdictional authorities may be resistant to additional oversight from a higher governmental level, based on the concern of losing touch with the needs of their constituents. Thus, efforts to regionally centralize permitting duties that will streamline the approval process and facilitate new installations should be done while balancing the concerns of local permitting officials with oversight from higher levels of government.

Centralization the permitting oversight can be a very effective way for facilitating the implementation of a new technology. One example of efforts to streamline the permitting

process at the State level is the current effort in South Carolina. This involves pending legislation that once approved, will centralize the permitting and approval process through the South Carolina State Fire Marshal's office and will significantly streamline the local installation of new facilities in South Carolina that use hydrogen.[88] Certain public and private statewide organizations (e.g. South Carolina Business One Stop, and South Carolina Hydrogen and Fuel Cell Alliance) are assisting to facilitate this initiative. This pending legislation provides a useful model for other regions or States that are interested in facilitating this type streamlined process.

4) REVIEW OF INCIDENT RESPONSE PROTOCOLS

The term "incident response" describes the actions taken by emergency first responders to implement immediate and ongoing activities, tasks, programs, and systems to manage the effects of an incident that threatens life, property, operations, or the environment. This describes how an entity (e.g. municipality) responds an emergency, disaster or other significant event that might impact the entity, and can include any measures necessary to bring an entity to a more stable status.[89] An emergency incident is defined as:[90]

> *Emergency Incident: Any situation to which an emergency services organization responds to deliver emergency services, including rescue, fire suppression, emergency medical care, special operations, law enforcement, and other forms of hazard control and mitigation.*

The purpose of this section is to provide additional detail on the incident response protocols that are typically used for managing an emergency event. Here, the focus is on hypothetical incidents involving hydrogen to provide a better framework to better understand these protocols. Additional details are provided by six case study jurisdictions to exemplify the common as well as different features of emergency incident response generally found in the United States.

Overview of Fire Service Emergency Response

Emergency incidents involving the use of hydrogen are normally viewed as a hazardous material event, and these will typically initiate special fire service operations. When an emergency incident of any kind occurs, multiple factors affect how the emergency first responders will respond and mitigate the incident. Key factors include, but are not limited to, the nature of the emergency, jurisdictional location of the incident, and the first responder resources available.

Fire Service Resources for Emergency Response

How fire service first responders handle an emergency relates to certain fundamentals, and of particular interest are emergencies involving a hazardous material such as might occur at a fixed-site installations using hydrogen or hydrogen fueled mobile vehicles. Among these, two primary considerations for determining the capabilities of first-arriving emergency responders to handle an emergency are: (1) the equipment and tools needed to address the emergency event; and (2) personnel trained to operate this equipment and tools.

Equipment and tools arriving at the scene of an emergency in mobile fire apparatus are generally referred to as companies and these are the basic operating fire service units in North America. These companies are staffed by trained fire fighters, and the number of fire fighters with each company will vary depending on the jurisdiction, the type of equipment, type of fire department (e.g. career or volunteer), and multiple other factors.[91, 92] While there is a broad

range of types of automotive fire apparatus, the two most common are the Pumper and Aerial Companies.[93] Additionally, many larger fire departments also utilize Rescue Companies that focus on certain rescue oriented functions.

All three of these are also referred to by other common names, such as "Engine" for Pumper Company, "Truck" or "Ladder" for Aerial Company, and "Squad" for Rescue Company. The following provides a brief description of each of these types of automotive fire apparatus:[94]

- *Pumper (a.k.a. Engine Company): Specializes in putting water on the fire by securing water source and deploying hand lines, and other duties such as search and rescue.*
- *Aerial (a.k.a. Truck or Ladder Company): Specializes in forcible entry, search and rescue, ventilation, roof operations, and other duties.*
- *Rescue (a.k.a. Squad): Specializes in search and rescue, technical rescue situation such as confined space or high-angle, and other duties that require specialized tools and training.*

These fire fighting companies compose the backbone of the U.S. fire service, and they're sometimes specialized to address certain unique fire fighting functions, such as wildland fires or aircraft rescue and fire fighting. Fire Departments will also often have additional mobile equipment, most notably Emergency Medical Services Companies (also commonly referred to as ambulances).

One specialized piece of mobile fire apparatus often found in large city departments and also on a regional basis for smaller or rural fire departments is a Hazardous Materials Company. They would be responsible for responding to and controlling an emergency scene involving hazardous materials that cause a threat due to leakage, spillage, fire, or other emergency. These units have special equipment and are staffed by fire fighters with specialized training.[95]

Even with the proper equipment and tools responded to an emergency, these fire service companies will only be as good as the trained fire fighter using them. Fire fighters receive extensive training on how to handle multiple types of emergency situations, including complex events like a hazardous materials incident. The level of training will vary from one fire service organization to another; however, in the United States there is significant consistency among the fire service in certain basic concepts and approaches. Consequently, the actions taken by the fire service responding to an emergency event, such as an event involving hydrogen, will have strong similarities despite the jurisdiction or department, and differ primarily based on the ability to provide trained staff and proper equipment to address the event.

The professional qualifications for career and volunteer fire fighter are addressed in significant detail by a family of 16 NFPA standards addressing the profession's minimum job performance requirements (see Figure 1-11 in Part 1: *Fire Service Primer*). Of these documents, NFPA 1001, *Standard for Fire Fighter Professional Qualifications* addresses mainstream structural fire fighters, and describes the fundamental duties of the basic fire fighter positions of "Fire Fighter

I" and "Fire Fighter II".[96] The NFPA standards on professional qualifications, like NFPA 1001, are widely used by the fire service in the United States.

The most basic qualified level of recognition for fire service response personnel is "Fire Fighter I" in accordance with NFPA 1001. A general knowledge requirement for "Fire Fighter I" is to meet specific requirements defined in NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, and specifically, NFPA 472 Chapter 5 on "Core Competencies for Operations Level Responders", and Section 6.6 on "Mission-Specific Competencies: Product Control". Figure 2-12 illustrates the core competencies required for operations level responders, including Fire fighter Level 1, at a hazardous materials incident.[97]

The basic levels of competencies for first responders at a hazardous materials event are: awareness, operations, technician, and command (also see Table 1-20 of Part 1: *Fire Service Primer*). In addition, a fifth level includes private sector specialists who supplement first responders with additional expertise. These are summarized as:[98]

- *First Responder at the Awareness Level: Personnel who, in the course of their normal duties, could encounter an emergency involving hazardous materials and who are expected to recognize the presence of the hazardous materials, protect themselves, call for trained personnel, and secure the scene.*
- *First Responder at the Operations Level: Persons who respond to hazardous materials incidents for the purpose of implementing or supporting actions to protect nearby persons, the environment, or property from the effects of the release.*
- *Hazardous Materials Technician: Persons who respond to hazardous materials incidents using a risk-based response process by which they analyze a problem involving hazardous materials, select applicable decontamination procedures, and control a release using specialized protective clothing and control equipment.*
- *Incident Commander: The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources.*

Because of the widespread use of these documents like NFPA 472 and NFPA 1001, fire fighters first on the scene of an emergency event involving hazardous materials (e.g. hydrogen) are likely to be similar in terms of their qualified capabilities. The widespread use of documents such as NFPA 472 and NFPA 1001 is partly due to the adoption of these and 25 other NFPA standards by the U.S. Department of Homeland Security.[99] Today a strong trend exists with fire departments conforming to these and other NFPA standards, based on the desire of local fire departments to work with DHS on intra-state mutual aid and to qualify for certain federal funding programs.

In the United States there are two major accrediting organizations for fire service personnel. These are the International Fire Service Accreditation Congress (IFSAC) and the National Board

on Fire Service Professional Qualifications (Pro Board). The memberships of both organizations include representatives from almost all states, and they operate on a "peer review "system using the NFPA professional qualification standards to accredit participating organizations. The fire departments in most U.S. jurisdictions function under either the IFSAC or ProBoard systems. Those that don't happen to use either of these systems still generally use the NFPA documents such as NFPA 1001 and NFPA 472[100] This results in significant operational consistency across the fire department in the United States despite their diversity as organizations.

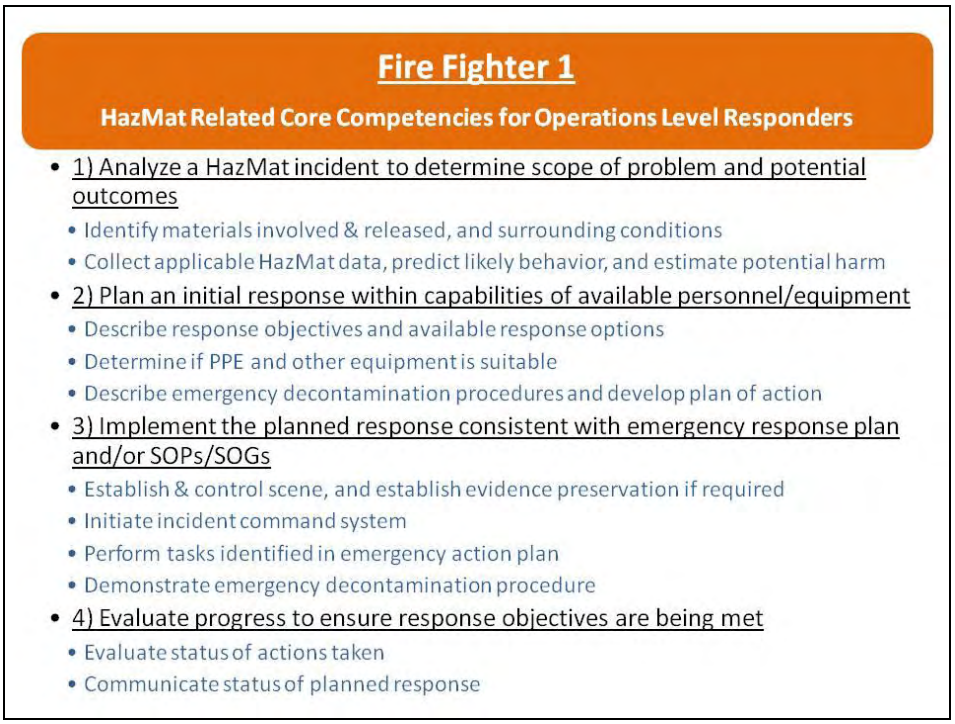

Figure 2-12: Core Competencies Required for HazMat Incidents Operations Level Responders[101]

In addition, numerous organizations provide either direct or indirect support to the fire service, and these have evolved over the years to fulfill specific express needs. The organizational types are quite varied, and include private non-profit membership associations, trade groups, state or federal government agencies, collective bargaining bodies, commercial enterprises, etc... (see Table 1-11 of Part 1: *Fire Service Primer*).

Fire Service Response to Incidents Involving Hydrogen

When emergency first responders from the fire service are called to address an emergency, what happens? Every emergency event is unique, and multiple factors will either simplify or complicate the event. These factors, for example, include the nature of the emergency, the installation or equipment involved, and the available resources of the first responders. For fixed-site installations using hydrogen, hydrogen fueled mobile vehicles, and other similar situations, it is useful to review certain fundamentals used by the fire service when responding to these types of incidents.

Even when dealing with a narrowly defined situation such as hazardous materials emergencies involving hydrogen, the range of possible variations of events is seemingly limitless. Table 2-4 summarizes ten possible situations that could be encountered in any community and by any local fire department. While installation such as a hydrogen refueling station might be less common, other situations that may confront responding fire fighters, such as industrial processing applications or accident involving bulk transport vehicles, are more common. In particular, transportation accidents could occur in any community.

Table 2-4: Possible Emergency Events Involving Installations with Hydrogen

DESCRIPTION	FACILITY / EVENT VARIABLES
Hydrogen Vehicle Refueling Station	Operations: Public / Private
	Bulk Storage: Above / Below-Ground
	Bulk Storage: Compressed Gas / Cryogenic Liquid
	Bulk Storage: Permanent Vessel / Transport Vehicle
Fixed Site Hydrogen Fuel Cell Emergency Power Supply	Remote Site with No Bldg Exposures (e.g. Cell Phone Tower)
	Part of Other Occupancy (e.g. High-Rise, Casino, Hotel, Hospital)
	Internal Fire / External Exposure Fire (e.g. Structure, Wildland)
Hydrogen Powered Industrial Lift Truck for Warehouse	Inside Warehouse / Outside Warehouse
	Internal Fire / External Exposure Fire
Industrial Processing in Manufacturing Plant with Bulk Storage	Internal Fire / External Exposure Fire (e.g. Structure, Wildland)
	Bulk Storage: Above / Below-Ground
	Bulk Storage: Compressed Gas / Cryogenic Liquid
	Bulk Storage: Permanent Vessel / Transport Vehicle
Residential On-Site Hydrogen Production for Motor Vehicle	Inside H2 Production / Outside H2 Production
	Bulk Storage / Minimal Storage
Motor Vehicle Accident	Release Without Fire / With Fire
	Without Entrapment / With Entrapment
	Without External Exposures / With External Exposures
Bulk Transport Highway Vehicle Accident	Release Without Fire / With Fire
	Without Entrapment / With Entrapment
	Without External Exposures / With External Exposures
Bulk Transport Railway Vehicle Accident	Release Without Fire / With Fire
	Without Entrapment / With Entrapment
	Without External Exposures / With External Exposures
Bulk Transport Maritime Accident	Release Without Fire / With Fire
	Without Entrapment / With Entrapment
	Without External Exposures / With External Exposures
Bulk Transport Pipeline	Above Ground / Under Ground
	Without External Exposures / With External Exposures

Certain variables can have a significant impact on the characteristics of an emergency event. For example, the likelihood of an accident is generally higher at a hydrogen vehicle refueling station if it is open to the public instead of a private facility only available to specially trained employees such as one exclusively serving a city bus fleet. As another example, remotely

located telecommunication facilities with small manifolded storage vessels present different hazards than a hydrogen fueled emergency power supply at a casino.

While there are multiple components of any facility, one that often receives additional focus is the bulk storage vessels. Additional factors relating to the bulk storage vessels include whether they are above ground versus below ground, compressed gas versus cryogenic liquid, or permanent vessel versus transport vehicle. These are examples of some of the features that may influence the nature of the emergency.

It would not be unusual for an emergency to involve multiple simultaneous hazards and threats. For example, a realistic scenario is a fire at a hydrogen vehicle refueling station caused by a motor vehicle crashing into the dispensing equipment. Certain variables will have significant effect on the decision making process of first responders, such as if victims are trapped within the fire area, or bulk storage vessels not involved with impact are exposed to the uncontrolled fire.

A key term often used by responding fire fighters is size-up. This describes the evaluation of problems and conditions that affect the outcome of the event.[102] This is an information-gathering process that includes all information know beforehand such as through pre-planning activities and details that can only be determined at the time of the event. All first responders implement their own size-up of the event, and this is especially important for incident commanders whose decision making process can have significant effect on the final outcome of the event.

The fire officer in charge at an emergency is the incident commander, and they are the manager of the emergency activities taking place at the scene. Despite the unique nature and the rapidly changing conditions of a typical emergency event, general management principals apply. In this regard, and consistent with Table 1-19 of Part1: *Fire Service Primer*, the five basic conceptual steps used to handle and administrate the event are:[103]

1) Planning;
2) Organizing;
3) Commanding;
4) Coordinating; and
5) Controlling.

These basic management principles translate into the primary responsibilities handled by an incident commander at the scene of an emergency. Table 2-5 provides a summary of the responsibilities of an incident commander at an emergency event.[104] While every event is unique, this provides a framework and basic approach used by first responders for mitigating a hazard and restoring conditions to a non-emergency status.

Most fire departments use Standard Operating Procedures (SOPs) or Standard Operating Guidelines (SOGs) to provide useful written operational and training information for the department.[105] While these SOPs/SOGs will vary from one department to another, they

generally include similar common baseline information. This provides coordination and a baseline understanding to guide the immediate actions taken by first-arriving emergency responders, such as size-up, call-for-help, rescue, confine & extinguish, overhaul, etc…[106]

Table 2-5: Primary Responsibilities of an Incident Commander at an Emergency Event[107]

INCIDENT COMMANDER RESPONSIBILITIES
(1) **Arrive on-scene** before assuming command
(2) **Assume and confirm command** of an incident and take an effective command position
(3) **Perform situation evaluation** that includes risk assessment
(4) Initiate, maintain, and **control incident communications**
(5) **Develop an overall strategy** and an incident action plan and assign companies and members consistent with the standard operating procedures
(6) **Initiate an accountability** and inventory worksheet
(7) **Develop an effective incident organization** by managing resources, maintaining an effective span of control, and maintaining direct supervision over the entire incident, and designate supervisors in charge of specific areas or functions
(8) Review, evaluate, and **revise the incident action plan** as required
(9) **Continue, transfer, and terminate command**
(10) On incidents under the command authority of the fire department, **provide for liaison and coordination** with all other cooperating agencies
(11) On incidents where other agencies have jurisdiction, **implement a plan that designates one incident commander** or that provides for unified command

These SOPs/SOGs provide useful informtion for responding fire fighters and they also serve as a basis for the occupational safety and health programs embraced by many departments, such as would conform to NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs*. The basic concepts to consider for occupational safety and health were illustrated in Figure 1-30 of Part 1: *Fire Service Primer*.[108] Further, the SOPs/SOGs work closely with fire fighting pre-planning activities and are coordinated with training and other on-going programs that depend on this documented information (see Figure 1-29 of Part 1: *Fire Service Primer*).

<u>Overview of Incident Command</u>

A critically important concept required for successfully handling a serious emergency incident is establishing a clear chain of command. Most important is clarifying the top of that chain, i.e., clarifying who is ultimately in charge of the emergency event.

The individual with overall command of the resources addressing an emergency event is referred to as the "Incident Commander" (IC). This individual has overall authority and responsibility for conducting incident operations and for managing all incident operations at the incident site. Specifically, the IC is defined as:[109]

> *"Incident Commander (IC)". The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources.*

Overall, the IC is the most important person in the Incident Management Team (IMT). The IMT are defined as:[110]

Incident Management Team (IMT). The incident commander and appropriate command and general staff personnel assigned to an incident.

An IMT is made up of the command and general staff members in an ICS organization. The professional staffs that fill the IMT positions are from an emergency service organization and are often pre-designated to ensure that they have the necessary training and experience to fulfill their assigned roles and responsibilities. The level of training and experience of the IMT members, coupled with the identified formal response requirements and responsibilities of the IMT, are factors in determining the Type of the IMT. The IMTs are generally classified as one of the following five types:[111]

- Type I: National teams;
- Type II: State or national teams;
- Type III: Regional or state, multi-agency or multi-jurisdictional teams;
- Type IV: Local agency- or jurisdiction-specific teams; and
- Type V: Local discipline-specific teams.

An IMT is a deployable unit, and they can be requested by the on-site IC for events that exceed local resources. They are structured to provide incident management assistance to complement and support the host organization handling the event. The emergency services organization can request the IMT to either perform incident support or provide incident management of the overall emergency event.

The IMT operates with the "Incident Management System" (IMS). The IMS is defined as:[112]

Incident Management System (IMS). A system that defines the roles and responsibilities to be assumed by responders and the standard operating procedures to be used in the management and direction of emergency incidents and other functions.

An IMS provides coordination, interoperability and compatibility among all the levels of government, the private sector, and volunteer organizations operating at an emergency incident. It provides a consistent yet flexible approach for all emergency responders, including government, private sector, and volunteer organizations to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity. The IMS includes a core set of concepts, principles, terminology, and technologies covering the incident command system, multiagency coordination systems, training, and identification and management of resources.[113]

For large-scale events that escalate and require additional personnel and equipment to a, the ICS can involve appreciable resources. Figure 2-13 provides an example of a typical incident command structure. This would be applicable for an incident involving a single emergency service organization in a single jurisdiction. A specific example would involve a large city fire department addressing a serious hazardous materials event with resources that are part of their department.

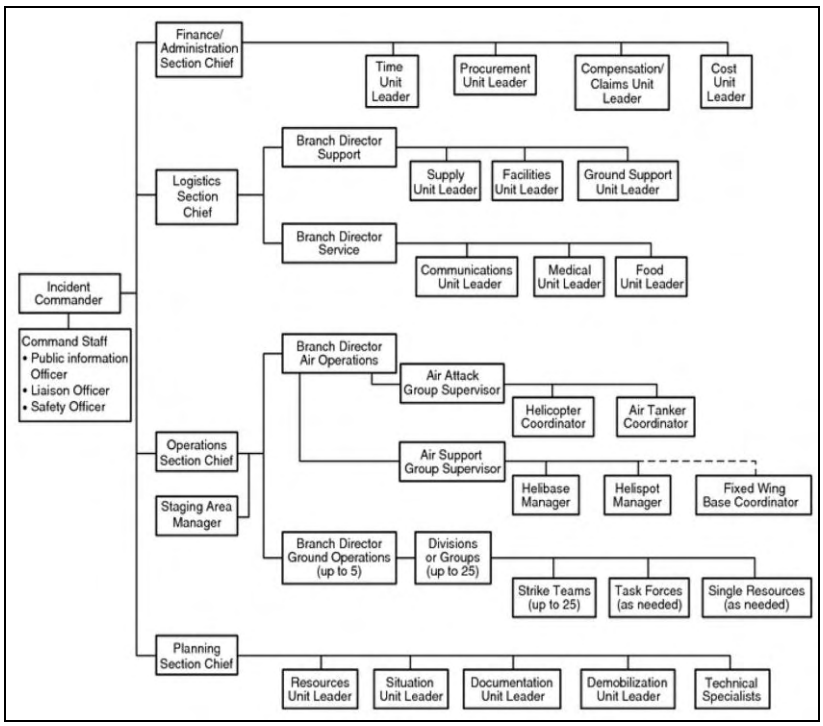

Figure 2-13: Typical Incident Command Structure for a Single Service and Single Jurisdiction[114]

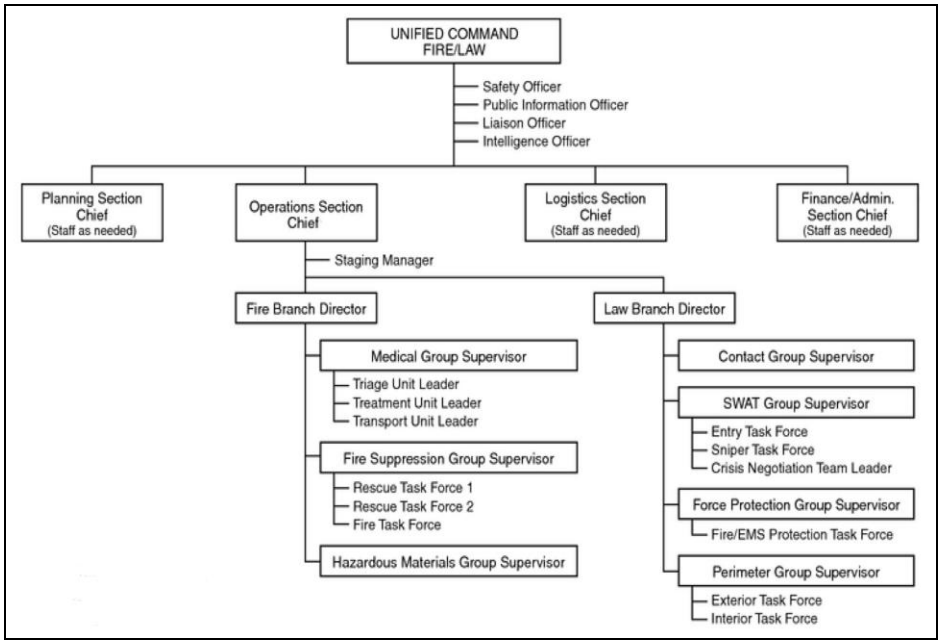

Figure 2-14: Typical Unified Incident Command Structure for Multiple Services[115]

For many events; however, there are multiple and separate emergency service organizations operating at the incident, each performing a specific role. The most common example of this is fire service and law enforcement services operating side-by-side at a major event. While the

fire service is focused on mitigating the fire, explosion or other hazard, the law enforcement service is focused on maintaining law and order.

For some events these objectives can become inexplicably intertwined, such as during a hazardous materials emergency caused by civil unrest, or a terrorist attack involving CBRNE (Chemical, Biological, Radiological, Nuclear, Explosive). Figure 2-14 illustrates a typical unified command structure for multiple services. However, this illustration is based on a single jurisdiction. Fortunately, additional prototypical models (and other extensive support information) are provided in the literature for situations involving multiple jurisdictions.[116]

Fundamentals of Emergency Management

The management of an emergency event is a dynamic process. In most cases, an unexpected emergency event will be first addressed at the local level. If local resources are not capable of effectively handling and eliminating the situation, additional assistance can be requested and utilized through agreements that will ultimately provide adequate resource allocation to mitigate the event.

Basic Levels of Government Emergency Service Organizations

In the United States the most critical resources that respond to an emergency event are those that are closest and able to provide immediate assistance. In most cases this will be the local government supported fire service or law enforcement service protecting that jurisdiction (e.g. town, village, city, county, or special district). The vast majorities of the emergencies that they respond to are routine and are mitigated within the capabilities of their staffing, equipment, and other resources.

If the event exceeds their available resources, these local emergency responders will turn to their neighboring municipalities in the region through mutual aid agreements. If the event dwarfs these resources, they are then able to approach the respective State government, who in turn can approach the Federal government if the State's resources are exceeded (e.g. natural disaster such as an earthquake or hurricane).

The basic levels of U.S. emergency service organizations that are government funded are shown in Figure 2-15. While these four levels are often present, variations will occur at the local and regional level, such as jurisdictions protected by large county fire departments that protect the jurisdiction defined by the county political boundary. However, all 50 States provide emergency management resources, and they in turn (along with the District of Columbia and U.S. territories) can turn to Federal support if needed.

One special case are the federally recognized tribal governments with the United States that operate as sovereign nations, and they in turn commonly have mutual aid agreements with their neighboring local communities as well as the respective State government and the U.S. federal government. In addition, one additional level not shown is international support, which

would occur with emergency events of international proportions and which fortunately are exceedingly rare.

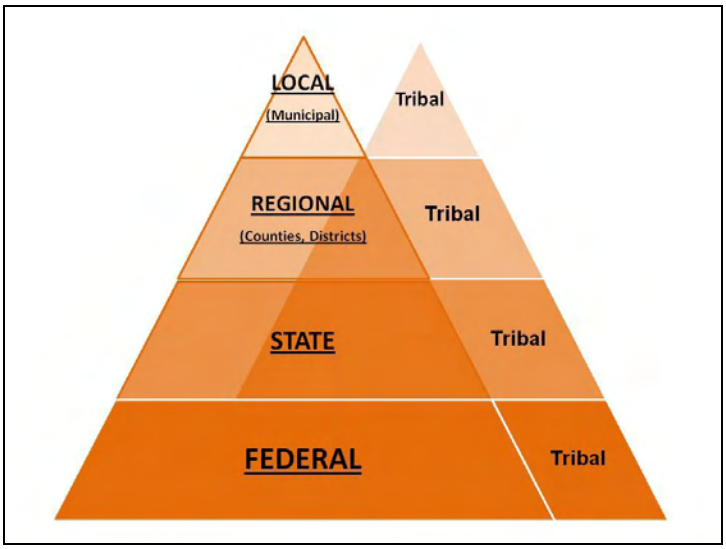

Figure 2-15: Basic Levels of Government Emergency Service Organizations in the United States

In some cases the event requires a higher level of support not so much to provide additional staffing, equipment and other resources, but instead to provide administrative coordination for large emergency events that occur on a jurisdictional boundary. An example may be a large scale hazardous materials event on a river between states, or train derailment on the state-line.

Mutual Aid Agreements and Assistance Agreements

These additional resources are provided through Mutual Aid Agreements and Assistance Agreements. Such agreements are between emergency response agencies, organizations, and jurisdictions, both governmental and non-governmental, and they provide a mechanism to quickly obtain emergency assistance in the form of personnel, equipment, materials, and other associated services.[117] The result is rapid resource deployment prior to, during, and after an event.

In the vast majority of emergency events, local resources and local mutual aid agreements and assistance agreements will provide the first line of incident response. If additional or specialized resources or capabilities are needed, these may be requested from available regional, state or federal resources. This process must be flexible for escalating or large-scale events, since some will occur with no-notice (e.g. hazardous material release, earthquake, some with-notice (e.g hurricane, approaching wildfire), and some will involve planned-events (e.g. large community convention, major sporting event).[118]

Background of Emergency Management in the United States

What we now call emergency management in the United States had its genesis with local efforts to address devastated 19th century cities and towns that experienced serious public health blights, city-wide conflagrations, and major natural disasters. In 1939 this took on more

official status at the national level when President Roosevelt established the Office of Emergency Management to safeguard all facilities that would play a role in an armed conflict if war came to America.[119]

Modern emergency management activities and organizations are more directly related to the post-World War II period civil defense initiatives that arose in response to Cold War threats. The threat of nuclear attack on U.S. soil led to the creation in the late 1940s of the Federal Civil Defense Administration by President Truman. During the 1970's the National Governor's Association sought a higher level of organization at the federal level with emergency management, and this was addressed in 1979 with the establishment of the Federal Emergency Management Agency (FEMA), which, among other duties, was given the responsibility for overseeing the nation's Civil Defense and with coordinating all disaster relief efforts at the federal level.[120]

In the last several decades as the Cold War threat has faded, FEMA has shifted their focus less toward nuclear attack and more toward other man-made and natural disasters. Several noteworthy events in the last decades have brought renewed attention to refining and enhancing emergency management approaches and concepts, most notably: Hurricane Andrew (Florida) in 1992; Oklahoma City bombing (Oklahoma) in 1995; terrorist attacks of September 2001 (New York, Virginia, Pennsylvania); and the 2004-2005 hurricane season (Florida, Louisiana, Mississippi, Texas). In 2003 the U.S. Department of Homeland Security (DHS) was created, and FEMA now exists within DHS.

A key document used by the emergency management arena is NFPA 1600, *Standard on Disaster/Emergency Management and Business Continuity Programs*. The first edition was first issued in 1995, and since that time it has had multiple updated editions. NFPA 1600 is an important guidance document that is widely used in North America and around the world for providing important guidance for programs dealing with emergency management and business continuity.[121]

Local Emergency Planning Committees

Certain emergency preparedness organizations assist with the planning and coordination of emergency management and incident response for emergency responders. These organizations meet regularly and network to help jurisdictions and/or groups of jurisdictions to meet their preparedness needs. They range from small committees to large standing organizations, and include groups, committees and organizations such as Citizen Corps, Community Emergency Response Teams, Critical Infrastructure Sector Coordinating Councils, and Local Emergency Planning Committees.[122]

Of particular interest for emergency events involving hydrogen are Local Emergency Planning Committees (LEPCs), which in-turn report up to State Emergency Planning Committees (SEPCs). Their origin can be traced back to the "Superfund Amendments and Reauthorization Act" (SARA) that was signed into federal law in October 1986, and specifically Title III of this act,

which is also known as the "Emergency Planning and Community Right to Know Act" (EPCRA).[123]

The purpose of EPCRA is to empower citizens and emergency responders with the right-to-know what chemicals exist in communities where they live and work. It mandates planning for chemical emergencies, and requires establishing a chain of command to assure that the requirements are met. Their primary responsibilities include:[124]

- Assisting local governments in developing hazardous materials emergency response plans.
- Evaluating the community's need for resources to respond to hazardous materials emergencies.
- Processing requests from the public for information on hazardous chemicals in their communities.

By Federal law administered through the U.S Environmental Protection Agency, every jurisdiction is required under EPCRA to have access to and involvement with an LEPC.[125] The LEPC provides the focal point for chemical emergency response planning and implementation for a specific pre-determined area within a particular State. Consequently, pre-planning for incident response for emergency incidents involving hydrogen is part of the focus of the LEPC for that jurisdiction.

For convenience, most states generally assign the LEPC's according to county jurisdictional boundaries, often with exceptions for larger metropolitan areas. A few states, however, assign them according to special regional areas (e.g. California).[126] The networking resulting from mandatory LEPCs has directly fostered fire service Mutual Aid Agreements and Assistance Agreements with a focus on hazardous materials events. For this reason, the LEPC is an important part of the incident response framework for installation involving hydrogen.

NIMS: National Incident Management System

In the United States today, the National Incident Management System (NIMS) is available for all emergency responders. For the fire service it is implemented at the Federal level, by all 50 States, and most if not all regional and local public fire departments. This provides significant consistency of operations and resources for an emergency event of any size, of any type, in any jurisdiction.

Thus, for an emergency such as a hazardous materials spill or an emergency involving hydrogen, and especially for events that escalate beyond the resources of the local fire department, NIMS provides the framework that will ultimately provide overall coordination and management of an incident that is exceeding available resources. How the incident is initially handled by the first arriving local fire department will of course differ based on immediately available resources such as staffing, equipment, training, and other factors, but as an incident escalates the mechanism is in place through NIMS for coordinated assistance.

The current NIMS has its roots in NFPA 1561, *Standard on Emergency Services Incident Management System*, when the first edition of this document was issued in 1990 to support requirements in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, which required that fire departments conduct emergency operations within an effective incident management system.[127] When the 2005 edition of NFPA 1561 was issued, it coincided with implementation of NIMS as component of a new National Response Plan (NRP) that is part of part of Homeland Security Presidential Directive/HSPD-5 on management of domestic incidents, which is administered and enforced through the U.S. Department of Homeland Security.[128]

The significance in the emergency management arena of Homeland Security Presidential Directive/HSPD-5, "*Management of Domestic Incidents"* cannot be overstated. HSPD-5 requires all federal departments and agencies to adopt the NIMS and to use it in their individual incident management and emergency programs and activities, as well as in support of all actions taken to assist state, tribal, or local entities. The directive requires federal departments and agencies to make adoption of the NIMS by state and local organizations a condition for federal preparedness assistance (through grants, contracts, and other activities).[129] As a result, the use of NIMS by emergency response organizations, and most notably the U.S. fire service, is unquestionably extensive.

Two other Homeland Security Presidential Directives are applicable for incident response protocols for hazardous materials events such as those that would possibly involve hydrogen. These are summarized in Table 2-6. First is Homeland Security Presidential Directive HSPD-7, "*Critical Infrastructure Identification, Prioritization, and Protection*".[130] This directs the DHS to establish a national policy for federal departments and agencies to identify and prioritize critical infrastructure and key resources to prevent, deter, and mitigate the effects of deliberate efforts to destroy, incapacitate, or exploit them. To accomplish this, Federal departments and agencies are required to work with State, tribal, and local governments, and other non-government and private sector organizations. Included is the DHS program to develop, implement, and manage and maintain the National Infrastructure Protection Plan (NIPP) that provides the unifying structure for integrating existing and future critical infrastructure and key resources protection.

Table 2-6: Homeland Security Presidential Directives Applicable to Emergency Management[131]

Directive Number	Homeland Security Presidential Directive Title
HSPD-5	Management of Domestic Incidents
HSPD-7	Critical Infrastructure Identification, Prioritization, and Protection
HSPD-8	National Preparedness

The second of applicable Homeland Security Presidential Directive is HSPD-8, "*National Preparedness*".[132] This directs DHS to lead a national initiative to develop a National Preparedness System that uses a common unified approach to strengthen the preparedness of the United States to prevent and respond to threatened or actual domestic terrorist attacks, major disasters, and other emergencies.

This has resulted in the National Preparedness Guidelines and establishment of a comprehensive approach to national planning in accordance with HSPD-8 Annex I, "*National Planning*". Annex I of HAPD-8 calls for the development and updating of an Integrated Planning System (IPS) which utilizes fifteen National Planning Scenarios and establishes the Target Capabilities List (TCL).[133] The TCL outlines an all-hazards approach to development of capabilities that will be needed for natural or manmade disasters or other major incidents, and defines the primary roles that all levels of government, NGOs, the private sector, and individuals have in national preparedness.

Emergency Management Organizations

Within the United States, the U.S. Department of Homeland Security (DHS) is the key federal government organization handling disaster management and homeland security. Before the establishment of DHS, homeland security activities were spread across more than 40 federal agencies.

Consideration of a new national security agency had been under review before the terrorist attacks of September 11, 2001, although these events accelerated its creation. In November of 2002, President Bush signed the Homeland Security Act of 2002 into law that formally established the U.S. Department of Homeland Security. On March 1, 2003, the Department of Homeland Security assumed operational control of nearly 180,000 employees from the incoming agencies and offices that came under the new cabinet level department.[134]

Homeland Security leverages resources within federal, state, and local governments, coordinating the transition of multiple agencies and programs into a single, integrated agency focused on protecting the American people and their homeland. More than 87,000 different governmental jurisdictions at the federal, state, and local level have homeland security responsibilities, and these are coordinated through DHS.

The specific agency with DHS handled emergency management and disaster preparedness is the U.S. Federal Emergency Management Agency (FEMA). The mission served by FEMA has existed in one form or another since 1803, and in 2003 FEMA became an agency within DHS.[135]

FEMA's primary mission is to reduce the loss of life and property and protect the United States from all hazards, including natural disasters, acts of terrorism, and other man-made disasters. FEMA acts on events of national interest through Washington DC, but they also provide direct assistance to specific municipalities through the ten local FEMA regional offices (see also Figure 1-23 of Part 1: *Fire Service Primer*). FEMA is the federal government agency that works directly with State level governments within the NIMS framework for large-scale disasters and activities requiring federal government resource.

At the State level, each of the fifty U.S. States (as well as the other jurisdictional regions administered by the Federal government) provides their own emergency management services. Table 2-7 provides a summary of the State government organizations with oversight for

emergency management services in their jurisdiction, and who serve as the primary contact point with the U.S. Department of Homeland Security

Table 2-7: State Emergency Management Organizations[136, 137]

STATE	State Government Agency, Department or Division	Typical State Membership Association
Alabama	AL Emergency Management Agency	AL Association of Emergency Managers
Alaska	AK Div. of Homeland Security and Emer. Management	AK State Emergency Response Commission
Arizona	AZ Division of Emergency Management	AZ Emergency Services Association, Inc.
Arkansas	AR Department of Emergency Management	AR State Emergency Response Commission
California	CA Governor's Office of Emergency Services	CA Emergency Services Association
Colorado	CO Office of Emergency Management	CO Emergency Management Association
Connecticut	CT Office of Emergency Management	CT Emergency Management Association
Delaware	DE Emergency Management Agency	State of DE Emergency Management Agency
Florida	FL Division of Emergency Management	FL Emergency Preparedness Association
Georgia	GA Emergency Management Agency	Emergency Management Association of GA
Hawaii	HA State Civil Defense	HA State Emergency Response Commission
Idaho	ID Bureau of Homeland Security	ID Emergency Management Association
Illinois	IL Emergency Management Agency	IL Emergency Services Management Assoc.
Indiana	IN Department of Homeland Security	Emergency Management Alliance of IN
Iowa	IA Homeland Security & Emerg. Management Division	IA Emergency Management Association
Kansas	KA Division of Emergency Management	KA Emergency Management Association
Kentucky	KY Emergency Management	KY Emergency Management Association
Louisiana	LA Office of Emergency. Preparedness	LA Emergency Preparedness Association
Maine	ME Emergency Management Agency	ME County Directors Association
Maryland	MD Emergency Management Agency	MD Emergency Management Association
Massachusetts	MA Emergency Management Agency	MA Association of Emergency
Michigan	MI Homeland Security &Emergency Management Div.	MI Emergency Management Association
Minnesota	MN Homeland Security & Emergency Management Div.	Association of MN Emergency Managers
Mississippi	MI Emergency Management Agency	MI State Emergency Response Commission
Missouri	MO Emergency Management Agency	MO Emergency Preparedness Association
Montana	MT Division of Disaster & Emergency Services	MT Assoc. of Disaster & Emergency Services
Nebraska	NB Emergency Management Agency	NB Association of Emergency Management
Nevada	NV Division of Emergency Management	NV State Emergency Response Commission
New Hampshire	NH Governor's Office of Emergency Management	NH State Emergency Response Commission
New Jersey	NJ Office of Emergency Management	NJ Emergency Management Association
New Mexico	NM Dept. of Homeland Security & Emerg. Management	NM Emergency Management Association
New York	NY State Emergency Management Office	NY State Emergency Management Assoc.
North Carolina	NC Division of Emergency Management	NC Emergency Management Association
North Dakota	ND Department of Emergency Services	ND Emergency Management Association
Ohio	OH Emergency Management Agency	Emergency Management Association of OH
Oklahoma	OK Office of Civil Emergency Management	OK Emergency Management Association
Oregon	OR Emergency Management	OR Emergency Management Association
Pennsylvania	PA Emergency Management Agency	PA Keystone Emergency Management Assoc.
Rhode Island	RI Emergency Management Agency	RI State Emergency Response Commission
South Carolina	SC Emergency Management Division	SC Emergency Preparedness Association
South Dakota	SD Division of Emergency Management	SD Emergency Management Association
Tennessee	TN Emergency Management Agency	Emergency Management Association of TN
Texas	TX Division of Emergency Management	Emergency Management Association of TX
Utah	UT Dept. of Emergency Services & Homeland Security	UT Emergency Management Association
Vermont	VT Emergency Management Agency	VT State Emergency Response Commission
Virginia	VA Department of Emergency Management	VA Emergency Management Association
Washington	WA State Emergency Management Division	WA State Emergency Management Assoc.
West Virginia	WV Div. of Homeland Security & Emergency Services	WV State Emergency Response Commission
Wisconsin	WI Emergency Management	WI Emergency Management Association
Wyoming	WY Office of Homeland Security	WY State Emergency Response Commission

Table 2-7 address all 50 states, and although equally recognized, for sake of brevity does not include the District of Columbia or U.S. Territories and Protectorates (i.e. American Samoa; Guam; Commonwealth of the Northern Mariana Islands; Republic of the Marshall Islands; Federated States of Micronesia; Republic of Palau; Puerto Rico; and the U.S. Virgin Islands).[138] It also provides an indication of at least one emergency manager's membership association for the local state members to facilitate their interests. In some cases this is an organization that has existing for many years, or possibly the State Emergency Response Commission that coordinates the Local Emergency Planning Committees required in all states by SARA Title III federal legislation.[139]

Regional networking and membership associations also exist that are not limited to a single state but cover the interest of multiple states. An example is the Northeast States Emergency Consortium (NESEC). This is a not for profit all-hazards emergency management organization established in 1991 and it is led by State Directors of Emergency Management for the states of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont.

Several national groups coordinate the interests of emergency managers on a national level. The two organizations handling these functions and that are most recognized are the National Emergency Managers Association and the International Association of Emergency Managers.

The National Emergency Managers Association (NEMA) was formed in 1974 and is based in Lexington, Kentucky. State directors of emergency management are the core membership of NEMA, and membership categories exist for key state staff, homeland security advisors, federal agencies, nonprofit organizations, private sector companies and concerned individuals.[140]

In 1990 NEMA became an affiliate organization with The Council of State Governments (CSG). CSG supports NEMA in its goals to provide an information and support network among State Directors of Emergency Management and to interface with other national and regional organizations involved in emergency management and state government policy in general. NEMA also administers the Emergency Management Assistance Compact (EMAC), established in 1996, which is the cornerstone of mutual aid agreements and partnerships between states, and has been ratified by Congress.[141]

The International Association of Emergency Managers (IAEM) was established in 1952 and is a non-profit educational organization dedicated to promoting the goals of saving lives and protecting property during emergencies and disasters. IAEM has members in 58 countries and has a mission to serve its members by providing information, networking and professional opportunities, and to advance the emergency management profession.[142]

Examples of Incident Response Protocols

Emergency incidents involving the use of hydrogen will normally be considered as a hazardous material event by fire service emergency responders. How a hazardous materials event is handled and mitigated is dependent on multiple factors, one of which is the size of the event and another being the immediately available resources provided by the emergency service organization.

This section provides additional focus is hypothetical incidents involving hydrogen based on informative details from six case study jurisdictions. This is intended to exemplify the common as well as different features of emergency incident response protocols generally found throughout the United States. The content of this information is neither correct nor incorrect, and this is not a summary of details intended for sake of comparison. Rather, it is offered to demonstrate the commonalities and differences associated with various incident response protocols associated with the fire service in the United States.

Los Angeles, California

The Los Angeles Fire Department (LAFD) provides fire service protection for more than 4 million people in America's second largest City. Nearly 3,600 uniformed personnel serve LAFD to protect the City's life, property and the environment through fire prevention, firefighting, emergency medical care, technical rescue, hazardous materials mitigation, disaster response, public education and community service. At any time of the day more than 1100 uniformed firefighters are staff the 106 neighborhood fire stations located across the 471 square-miles within the City of Los Angeles.[143]

LAFD has multiple hazardous materials task forces and hazardous materials squads that are suppression companies generally responsible for tactical operations at a hazardous materials incident. The first alarm response for a confirmed hazardous materials event would be supplemented by one Haz Mat task force with one Haz Mat Squad, one battalion chief, one rescue ambulance, and one senior paramedic.[144]

The hazmat response approach used by LAFD originated by converting three engine companies (stations 4, 27 and 39) into hazmat squads, and these served the dual function of responding to structural fires and hazardous materials incidents. At structural they served as additional manpower since they had no pumping capabilities. Their approach is to abate the hazard and render the threat to a nonhazardous condition, and then turn the scene over to the other agencies such as the LA County Health Department, LA Police Department, State Fish and Game, or other agency with responsibility depending on the situation.[145]

In 1983 the City of Los Angeles adopted an underground tank ordinance that initiated LAFD's involvement with environmentally-related programs. This expanded to include a disclosure program to identify hazardous materials used, stored and processed by City businesses. Subsequent State legislation created the Unified Hazardous Waste and Hazardous Materials Management Regulatory Program (Unified Program).[146]

At that time there were six individual state programs that regulate business and industry's use, storage, handling and disposal of hazardous materials and hazardous wastes. In 1994 these were consolidated under State legislation to be part of a single environmental control program managed by a Certified Unified Program Agency (CUPA) at the city or county level. These are known by the acronym CUPA for Certified Unified Program Agency, and it indicates that a city of county has the appropriate capabilities to handle all aspects of a hazardous materials event.[147]

In 1997 LAFD obtained CUPA certification for Los Angeles. Other cities in Los Angeles County that also have been certified by the state to be CUPA's for their jurisdiction are: El Segundo, Glendale, Long Beach/Signal Hill, Santa Fe Springs, Santa Monica, and Vernon. In addition, Los Angeles County has been certified by the state to be a CUPA for County areas not covered by a city that has CUPA certification.[148]

Los Angeles is similar to other large cities in that they have an Office of Emergency Management. For natural or manmade accidental events of high consequence, they provide comprehensive emergency management among the LAFD, LA Police, and other involved LA City resources. The LAFD incident commander still has responsibility for the fire service control of a hazardous materials event, but defers to other agencies for services outside their normal responsibility (e.g. crowd control, vehicle traffic etc).[149]

At the state level, the California Emergency Management Agency is divided into three administrative regions for purposes of emergency management. The City of Los Angeles is in the Southern Region. In addition, the state has six Local Emergency Planning Committees, and Los Angeles is in Region I, Area A.[150]

California has a statewide fire department that is unique among state governments. This is provided through the California Department of Forestry and Fire Protection (CDF), and is also referred to as “CAL FIRE”.[151] CDF provides emergency response and protection of natural resources, and it includes the Office of the State Fire Marshal. Their mission is to serve and safeguard the people and protects the property and resources of California. They achieve their mission by protecting lives, property and natural resources from fire and other emergencies, and working to preserve timberlands, wildlands, and urban forests.

CDF has extensive operational personnel and equipment located throughout the state protecting over 31 million acres of California’s privately-owned wildlands, and providing emergency services through local government agreements within 36 of California’s 58 counties.[152] As an example of their extensive statewide coverage, Figure 2-16 illustrates the base Fire Hazard Severity Zone Map that’s used as the root-map for multiple County maps delineating local responsibility versus state responsibility.

To provide an idea of available CDF operations resources, based on 2008 data they operated out of 803 fire stations, 21 aircraft and helicopter bases, and 39 conservation camps.[153] Their

operational equipment at that time included: 1,095 fire engines, 38 aerial ladder trucks; 215 rescue squads; 63 paramedic units; 58 bulldozers; 12 hazmat units, 23 air-tankers, 14 tactical airplanes, 11 helicopters, and multiple additional support units. Because of CDF's size and major incident command experience, the department is often asked to assist or take the lead in disasters within the State.

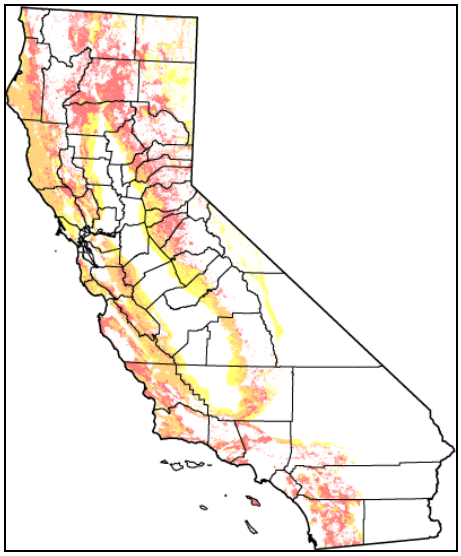

Figure 2-16: California Fire Hazard Severity Zone Map provided by CAL FIRE[154]

The manners in which the resources of CAL FIRE interact with the local resources in jurisdictions such as the City of Los Angeles are portrayed in Fire Hazard Severity Zone Maps administered by CDF. Figure 2-17 illustrates the maps for Los Angeles County which includes the incorporated areas of the City of Los Angeles.

Jefferson County, Colorado

The West Metro Fire Protection District is protected by West Metro Fire Rescue (WMFR) and was established in January 1995 as a result of the consolidation of Lakewood and Bancroft Fire Protection Districts. The District is governed by a board of seven publicly elected officials, and is a special district in the state of Colorado that operates independently of political boundaries.[155]

WMFR operates 15 fire stations that protect all or portions of the following Colorado communities: Golden; Lakewood; Littleton; Morrison; and Roxborough/Littleton. The district covers approximately 110 square miles in Jefferson County and in parts of Douglas County, covering the western suburbs of the metropolitan Denver area. The department has 287 career firefighters and 59 civilian administrative staff, and they provide emergency medical services (i.e. ambulances) in addition to fire services. First alarm response to an unconfirmed fire service call normally includes two engines/squirts, one ladder truck, one rescue squad, one ambulance, one District Chief, and one Safety and Medical Officer.

For confirmed hazmat incidents, WMFR operates a designated hazmat squad out of a station located in Golden Colorado, and in addition houses a hazardous materials decontamination vehicle at a fire station in Lakewood Colorado that belongs to Jefferson County. Selected WMFR fire fighters are specially trained for hazmat response, and their equipment includes a wide range of mitigation and decontamination equipment.[156]

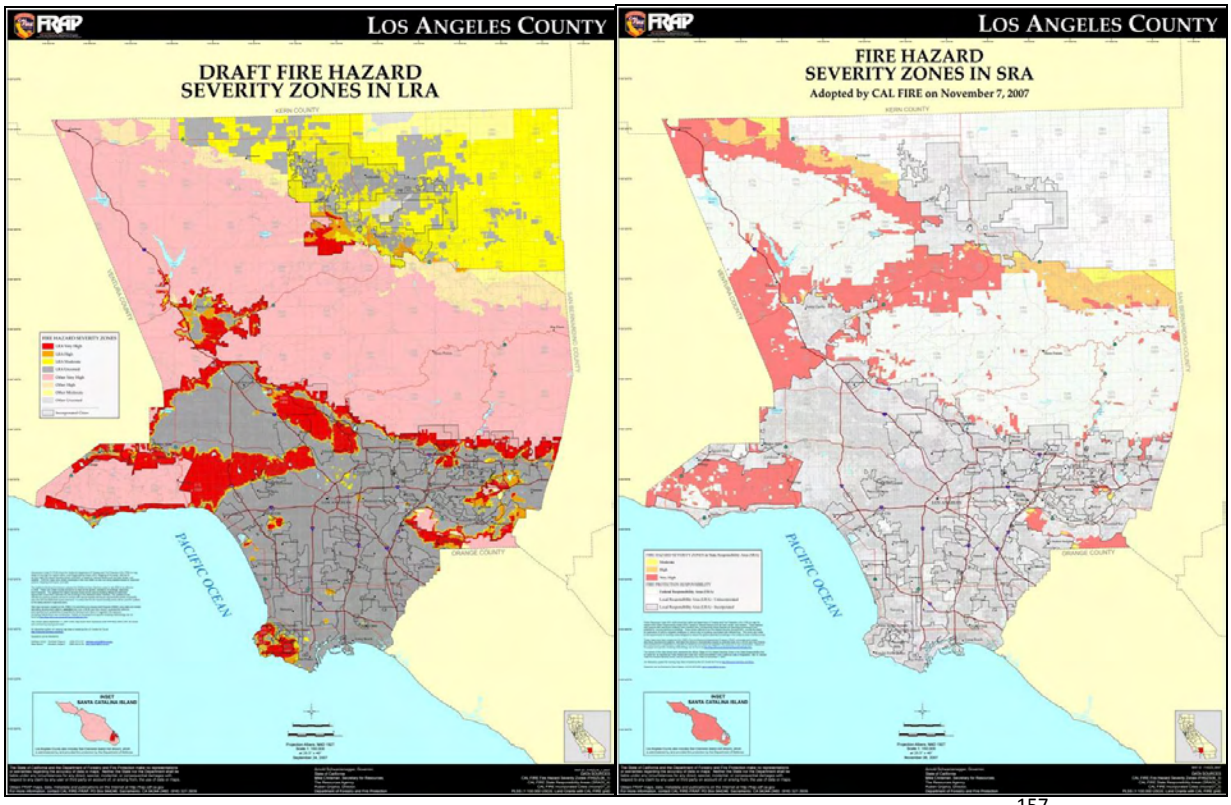

Figure 2-17: Los Angeles County Fire Hazard Severity Zone Maps[157]
(Local Responsibility Area on left, and State Responsibility Area in right)

For a confirmed hazardous material incident in the West Metro Fire Protection District, WMFR will work closely with the resources of the county and several other agencies. In Jefferson County this involves the Jefferson County Hazmat Response Team, which operates under the Jefferson County Sheriff's Department, Office of Emergency Management. For fire districts within the County that have hazardous materials response capability, such as WMFR, the County Hazmat Team provides supplemental resources for handling the event. Meanwhile, for unincorporated parts of Jefferson County (approximately 185,000 residents) they are the primary response.[158]

As an additional important hazmat response resource, in Colorado all confirmed hazmat incidents are initially treated as a crime scene. This results in the response of the Colorado State Patrol Hazardous Materials Unit. The Colorado State Patrol provides law enforcement services throughout the state, and their resources are available to all state-wide jurisdictions through the deployment of at least 24 fully trained and equipped Hazardous Material

Specialists (who are also State Troopers). These Hazardous Material Specialists are deployed in 12, two-person teams assigned throughout the state on an as-needed basis.[159]

Planning for a hazardous material emergency incident is directly addressed by the Local Emergency Planning Committee. In Colorado, the LEPCs are generally assigned according to the political boundaries of Colorado's 64 counties.[160] The Jefferson County LEPC reports to the Colorado Emergency Planning Commission (CEPC), which is administered by the Colorado Division of Emergency Management. The CEPC provides administrative oversight for Colorado's designated Local Emergency Planning Districts and their respective LEPCs. This results in establishment of a hazardous material emergency response plan and fulfillment of other SARA/Title III requirements.[161]

Large-scale emergency events in Colorado are coordinated at the state level by the Colorado Division of Emergency Management, which is an agency under the Colorado Department of Local Affairs. This would include an extensive hazardous materials event that would require coordination through the state, and is the gateway for obtaining additional federal resources if necessary. In terms of natural disasters, during certain seasons the State of Colorado is prone to wildfire events, requiring regular utilization of this incident management system.[162]

<u>New York City, New York</u>

New York City, New York is one of the most populated cities in the world, and the largest in the United States with more than 8.2 million people within 322 square miles based on 2006 estimates. The New York City Fire Department (FDNY) provides fire and EMS service protection for its citizens with approximately 11,500 uniformed fire fighters, 3,000 EMS providers, and 1,600 administrative staff. In 2008 they had 221 fire stations and 30 EMS stations providing these services.[163]

Included within the extensive personnel and equipment resources of FDNY are units with hazardous materials capabilities, including four haztech engines, 35 haztech ambulances, and one special hazmat company. The typical response for a confirmed hazardous materials incident within the city, such as fire involving hydrogen, would result in at least the following response: 4 Engine Companies; 2 Ladder Companies; 1 Rescue Assist Ladder Company; 1 Rescue Company; 1 Hazardous Materials Technician Unit; 1 BLS Ambulance; 2 Battalion Chiefs; 1 Deputy Chief; 1 Haz-Mat Battalion; and 1 Haz-Mat Condition Officer. For large scale events these resources would be supplemented by striking additional alarms.

The New York City Office of Emergency Management provides coordination among the city's multiple emergency services during a large event, including the services provided by FDNY. In operation since the post World War II era and re-organized in 1996, the office plans and prepares for emergencies, disseminates public preparedness information, and provides coordination for emergency response and recovery operations. While the emergency response capabilities of the entire country were tested by the terrorist attacks of September 11, 2001, New York City was particularly challenged with the loss of hundreds of fire service and other

emergency responders, and the destruction of the Office of Emergency Management command center located in the World Trade Center complex.[164]

The State of New York coordinates the State Emergency Response Commission (SERC) through the State Emergency Management Office (SEMO). The various Local Emergency Planning Committees throughout the state report to and are coordinated by SERC, providing the necessary hazardous materials planning and reporting function in accordance with SARA/Title III requirements. For administrative purposes the state is separated into five regions, with multiple LEPCs in each region according to county political boundaries. The City of New York City has its own LEPC, and is part of Region one along with Nassau and Suffolk Counties on Long Island.[165]

Aiken, South Carolina

The City of Aiken, South Carolina is a smaller sized metropolitan area with a population estimated at 29,000 residents occupying about a 16 square mile area. Aiken is located in Aiken County on the Southwest side of South Carolina, and fire protection is jurisdictionally based on a special fire district as agreed to by the city council and the local Aiken County Council. The City of Aiken Fire District loosely follows the City of Aiken political boundary, but also includes several additional unincorporated areas of Aiken County.

The Aiken Department of Public Safety is a combined services department and simultaneously provides both fire service and law enforcement service for the community. The Department provides all the services expected of both services (e.g. fire fighting response, fire safety education, hazardous materials response, fire investigations, crime prevention, traffic control, patrol services, etc).[166] Fire apparatus at the city's four fire stations each have a dedicated fire fighter assigned around the clock to that particular unit. When a fire emergency is reported, the fire apparatus responds with the driver and patrolling law enforcement officers in police squad cars respond independently, thus providing the necessary additional staffing required for fire fighting operations.

Certain emergency services for the City of Aiken are provided by Aiken County. For example, emergency medical services are delivered on a county-wide basis by the Aiken County Emergency Services. The County also provides support for certain specialized fire service operations. One of these includes hazardous materials response. This supplemental resource is provided by the Aiken County Emergency Service Hazmat Division, consisting of approximately 35 trained staff members and volunteers. Through mutual aid agreements they supplement the City of Aiken Department of Public Safety when handling a confirmed hazardous materials event.[167]

The City of Aiken and Aiken County emergency service providers are fortunate to have the Department of Energy Savannah River Site in their general vicinity, which operates a fully staffed and equipped fire department larger than most municipal departments in the region. Because of the unique hazards at the Savannah River Site, the Savannah River Site Fire

Department is specially trained to handle certain hazardous materials emergency events, and therefore also provide a valuable mutual aid resource to the surrounding region.[168]

This was the case with a train derailment incident in January of 2005 in the community of Graniteville South Carolina (adjacent to Aiken City), which ultimately was one of the nation's more recent large-scale hazardous materials events. This involved a chlorine gas cloud release that resulted in 9 fatalities, 552 injuries, and more than 5,400 residents evacuated. Ultimately 111 different agencies participated in the response over a 10 day period, including the Savannah River Site Fire Department and additional hazardous materials experts.[169]

The Local Emergency Planning Committee for the City of Aiken, which handles planning/reporting for hazardous materials events, resides with the Aiken County Emergency Management Division. They in-turn report up to the South Carolina Emergency Management Division, which has responsibility for the development, coordination, and maintenance of the South Carolina state-wide Emergency Operations Plan, Hurricane Plan, Earthquake Plan, Terrorism Plan, and selected other plans. In addition, they also have responsibility for the operation and maintenance of the State Emergency Operations Center.[170]

Houston, Texas

The City of Houston, Texas is the fourth most populated city in the United States, with more than 2.1 million residents in 2006 in a jurisdiction that is approximately 600 square miles. The city is protected from fire and related emergencies by the Houston Fire Department (HFD).

As of 2008, HFD had approximately 4,000 uniformed fire fighters staffing 90 fire stations located throughout the city, and additionally have more than 260 administrative personnel. The HFD also has fire service responsibility for the Houston airports and the Port of Houston which is protected by 5 fireboats. The department is equipped with extensive hazardous materials resources, and this includes 6 hazmat units supporting a network of decontamination task forces and trailers strategically located throughout the City.[171]

HFD and the fire departments in the region have had a long history of handling hazardous materials emergencies. This is partly because the Port of Houston is one of the busiest seaports in the United States, and similarly, the Houston Ship Channel has one of the largest concentrations of refineries and petrochemical plants in the world. The Houston Ship Channel terminates in the city of Houston, but is also within the jurisdiction of multiple other fire departments from municipalities such as Pasadena, La Porte, and Baytown. The channel provides a naturally deep waterway that connects the City of Houston with Galveston Bay and ultimately the Gulf of Mexico.

Fire emergency services are coordinated for the Houston Ship Channel through the Channel Industries Mutual Aid (CIMA). CIMA is a non-profit organization established in 1955 whose member organizations include municipalities, government agencies, and industrial companies. The CIMA resources are coordinated into four geographic operational response zones, and their resources include highly trained personnel staffing more than 200 pieces of specialized

equipment provide fire-fighting, rescue, hazardous material handling, and emergency medical capabilities for the refining and petrochemical industry in this area.[172] In addition, HFD has mutual aid agreements with surrounding municipalities other than the port activities addressed by CIMA.

The City of Houston has its own Local Emergency Planning Committee, which is one of 18 LEPCs coordinated by Harris County. This and the other LEPCs promote emergency planning, preparedness, and public awareness to protect Houston and the vicinity from the potential impact of hazardous chemical substances and related disasters. Conveniently, Harris County also includes the jurisdictions that are involved with CIMA in the Houston Ship Channel, and this provides an additional level of coordination for handling of hazardous materials events in the region. Figure 2-18 illustrates the LEPCs in Harris County Texas, which includes the City of Houston and the Houston Ship Channel.[173]

Responsibility for emergency management activities in Harris County, Texas are handled by the Harris County Office of Homeland Security and Emergency Management.[174] The county judge is the ultimate authority for emergency management operations at the county level. Harris County is one of 254 counties in Texas, and their LEPC emergency management activities report at the state level to the Governor's Division of Emergency Management.

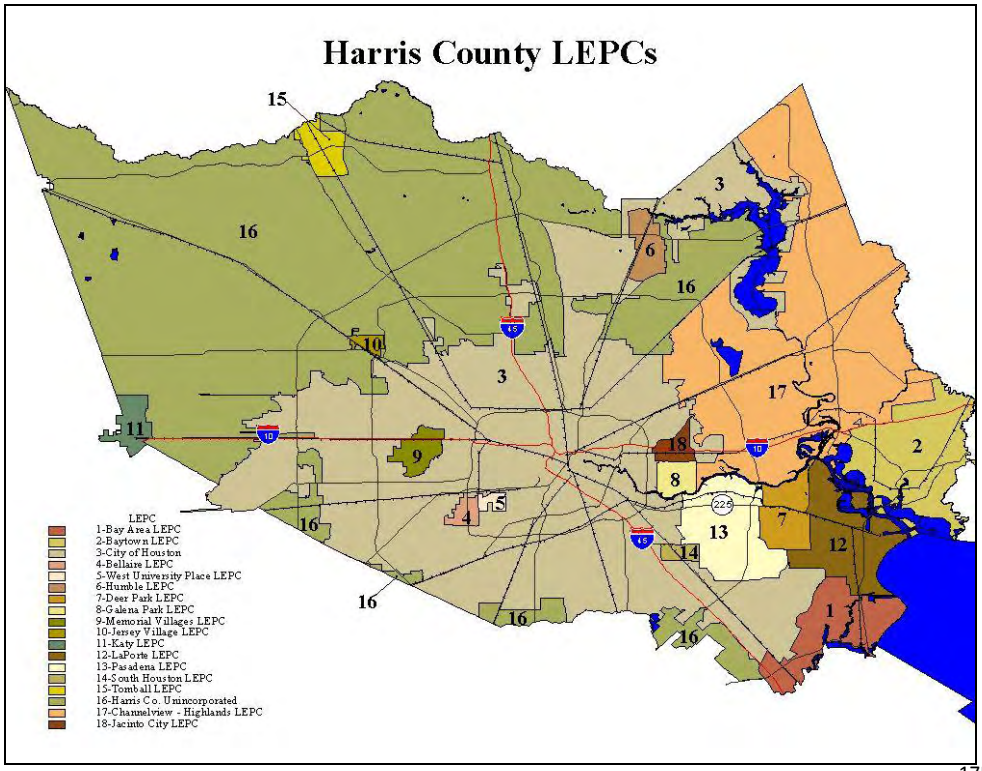

Figure 2-18: Local Emergency Planning Committees in Harris County, Texas[175]

The Governor's Division of Emergency Management (GDEM) that operates under The Texas Department of Public Safety is the governmental emergency management group in Texas that

has primary state-wide oversight.[176] With roots from the civil defense programs established during World War II, they have had multiple organizational names before the Texas Disaster Act of 1975 applied the Division's current name and assigned them a wide range of responsibilities. These include carrying out a comprehensive all-hazard emergency management program for the State and for assisting cities, counties, and state agencies in planning and implementing their emergency management programs. GDEM is also responsible for supporting development of the Governor's Homeland Security Strategy and implementing programs and projects to achieve state homeland security goals and objectives.

The Texas coastal area is no stranger to disasters, and historically has experienced several noteworthy events that have helped shape and refine their current emergency management system. This includes the Galveston Hurricane of 1900 (deadliest natural disaster in U.S. history with approximately 8,000 fatalities) and the Texas City Ship Explosions of 1947 (approximately 500 fatalities).[177, 178] More recently the coastal area of Texas, including the City of Houston, again had its emergency response system challenged by the massive evacuations caused by Hurricane Ike in 2007.

Texas, like other states, has a helpful networking association available for local Texas emergency managers. This resource is provided by the Emergency Management Association of Texas (EMAT), whose purpose is to promote and advance the professionalism of emergency management and disaster preparedness in Texas.[179] When EMAT was established in 1987, perhaps most notable among the existing Texas emergency management organizations was the *Texas Gulf Coast Emergency Management Association* (TCGEMA). TCGEMA was a regional organization focused on coastal areas of Texas and dedicated to saving lives and protecting property during times of emergency and disasters. In 2007, TCGMA was formally incorporated into the membership of EMAT.[180]

Organizationally EMAT is dedicated to the advancement of the field of emergency management both statewide and nationally, and to that end, they engage in an array of efforts to advance a statewide emergency management agenda. Among other tasks, they provide input into The Texas Fire and Rescue Mutual Aid Plan, which is an extension of and supportive document to the State of Texas Emergency Management Plan.[181]

<u>Dane County, Wisconsin</u>

Dane County is a typical county jurisdiction with a population of more than 470,000 located in the South-central portion of the state. They provide government services for areas within the County that range from smaller unincorporated jurisdictions such as Madison Township (population ~7,000) to larger jurisdictions such as the City of Madison (population ~220,000).

As an example of a smaller jurisdiction within Dane County, the Town of Madison provides a well-equipped and well-trained fire department of 65 members, delivering fire and emergency medical services for its residents.[182] The available emergency service resources are typical for a municipality of this size, and a confirmed hazardous materials emergencies within their

jurisdiction would require additional assistance. These resources are automatically provided by mutual aid agreements from the surrounding communities.

The City of Madison provides an example of a larger fire department within the County, and they utilize 11 fire stations staffed by more than 320 commissioned and non-commissioned personnel. In addition to their normal fire fighting and EMS duties, the department also supports a hazmat team that in parallel serves the State of Wisconsin by responding to hazardous material incidents in the regional area.[183]

Dispatch for Dane County is administered through a Public Safety Communications Center that operates a countywide 911 emergency call-taking service. This centralized dispatch activity immediately clarifies any jurisdictional response questions and provides communications and dispatching services to 26 local fire departments and 21 local EMS agencies throughout the county.[184]

For a confirmed hazardous materials event, resources in Dane County are available at the County level for a higher level operational response. This is coordinated through the Dane County Local Emergency Planning Committee, which operates under the Dane County Department of Emergency Management. Dane County, like the 72 other counties throughout Wisconsin, operates in coordination with other county emergency management activities. When and where necessary their efforts are coordinated at the state level by the Wisconsin Emergency Management Department of Military Affairs.[185]

Emergency management professionals involved with the Dane County Local Emergency Planning Committee may also be members of the Wisconsin Emergency Management Association (WEMA). WEMA is an association of people and businesses in Wisconsin interested in promoting effective emergency management planning, training and exercise programs. Their purpose is to advocate, promote and represent statewide emergency management interests for the ultimate purpose of enhancing the safety and security of all citizens.[186]

5) PART 2 SUMMARY OBSERVATIONS

This report provides a detailed examination of certain features and characteristics of the fire service in the United States. Specifically, the information contained herein illustrates the common features and diverse nature of: (1) the permitting infrastructure used by the fire service to allow buildings and facilities to be occupied; and (2) the protocols used for incident response to an emergency event.

Six specific jurisdictions are reviewed in detail to exemplify the characteristics they have in common as well as certain details which make them unique. This exercise is based on the hypothetical implementation of a commercial hydrogen refueling station and hydrogen back up power installations for a telecommunication cell phone tower.

The goal of this effort is to improve the transfer of hydrogen safety information to and from the fire service. The fire service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. This effort provides an overview of the U.S. fire service and information as to how to communicate with the U.S. fire service in key jurisdictions.

The following are specific observations that can be found throughout this report and summarized here for convenience:

Permitting Process Fundamentals

- Review at the county or state level may be required in addition to local review.
- The appropriate jurisdictional official should be involved in the planning, implementation and construction process as early as possible.
- Every new installation is unique, but generally new installations that are similar to existing installations will face less approval challenges from the safety infrastructure.
- The primary basis for determining hydrogen quantities that require a permit are set by the model fire codes (i.e. NFPA 1 Fire Code and International Fire Code), and these threshold values are widely used by the applicable authorities having jurisdiction.

Permitting Infrastructure

- The Local Fire Marshal and the Local Building Official are most often the key individuals involved in the permitting process.
- Local Fire Departments are often focused on the on-going operation of a building, while local Building Departments are often focused on the new construction of a building.

- Review by other local boards and commissions (e.g. environmental commission or a historic preservation board), is possible and varies depending on the particular installation.
- Review by a local zoning board or commission is often (but not always) required prior to or during the permitting process.

Clarifying Jurisdictional Authority

- Three key factors that influence jurisdictional authority are: (1) Property Owner (2) Geographic Location; and (3) Type of Occupancy.
- Buildings and facilities owned by the State or Federal government are a common exception to the local permitting process, and other exceptions include tribal and sovereign nations, and port authorities.
- One of the first steps in determining who to approach for a new building or structure is to clarify the applicable jurisdiction responsible for the specific geographic location.
- The occupancy classification of the building or structure may affect the permitting requirements, such as with residential occupancies using hydrogen fuel.

Topics of Interest to Permitting Officials

- Utilizing equipment that is "listed" by a nationally recognized testing laboratory will significantly facilitate the review process required by permitting officials for facilities using hydrogen.
- The risks between permanently installed hydrogen bulk storage vessels for hydrogen and portable hydrogen bulk storage vessels (e.g. over-the-road trailer) are not universally agreed upon by Authorities Having Jurisdiction.
- Unique installations unfamiliar to the Authority Having Jurisdiction are more likely to require special permitting review and require longer processing time.
- Regional centralization of permitting duties will streamline the approval process and facilitate new installations, but also requires balancing the concerns of local permitting officials with oversight from higher levels of government.

Overview of Fire Service Emergency Response

- Emergency incidents involving hydrogen are normally viewed as a hazardous materials event.
- Multiple factors can affect an emergency involving hydrogen, and it is not unusual for an emergency to involve multiple simultaneous hazards and threats (e.g. hydrogen fueled motor vehicle crash with entrapment at a refueling facility)
- Every jurisdiction in the United States is covered by a Local Emergency Planning Committee (LEPC) to assist with the planning and reporting of hazardous materials events.

- National standards (e.g. NFPA standards) provide and promote consistency among fire service emergency responders to hazardous materials events.
- Fire departments have strong incentive to follow national standards as a prerequisite for complying with certain funding programs currently administered by the U.S. Department of Homeland Security.
- Multiple regional and national resources support the U.S. fire service and assist with establishing consistency for activities such as operations, prevention, and training.
- Two primary considerations for determining the capabilities of first-arriving emergency responders to handle an emergency are (1) the equipment and tools needed to address the emergency, and (2) personnel trained to operate this equipment and tools.
- Most fire department use Standard Operating Procedures (SOPs) or Standard Operating Guidelines (SOGs) to provide written operational and training information.

Fundamentals of Incident Command

- The "Incident Management System", involving "Incident Command" and the "Incident Management Team", is widely used by the fire service in the United States.
- The "National Incident Management System", administered through U.S. Department of Homeland Security, is widely used by the fire service and other emergency response organizations in the United States.
- Each State has an Emergency Management Agency that provides state oversight of large-scale emergency events.
- The key overarching organization in the U.S. federal government directly involved with handling large-scale disasters is the Federal Emergency Management Agency under the U.S. Department of Homeland Security.

Background on Emergency Management

- Most emergency events are first addressed at the local level.
- Management of an emergency event is a dynamic process.
- If the capabilities of responding resources are exceeded, additional public and private resources are requested from: (1) other local; (2) regional; (3) state; and (4) federal resources.
- A higher level of emergency management support may be requested to provide additional resources, or to help coordinate multiple emergency services and/or multiple jurisdictions.
- Mutual Aid Agreements and Assistance Agreements are an important concept in the emergency response infrastructure.
- Most states have independent membership associations that coordinate the interest of local emergency managers in that particular state.

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ANNEX A: DEMOGRAPHICS OF CASE STUDY JURISDICTIONS

Table 2-8 provides a summary of basic demographic information for each of the six jurisdictions. This includes the population and the population change, as well as the land area and persons per area. This demonstrates the diversity of these jurisdictions with populations ranging from roughly 8.2 million (New York City) to just under 29, 000 (Aiken, SC).

Table 2-8: Population and Land Area Demographics for Case Study Jurisdictions[187]

	LOS ANGELES, CALIFORNIA	JEFFERSON COUNTY, COLORADO	NEW YORK CITY, NEW YORK	AIKEN, SOUTH CAROLINA	HOUSTON, TEXAS	DANE COUNTY, WISCONSIN
Population (2006 Estimate)	3,849,378	533,339	8,214,426	28,829	2,144,491	482,705
Population Percent Change (1/Apr/2000 - 1/Jul/2006)	+4.2%	+1.5%	+2.6%	+11.1%	+8.8%	+13.2%
Land Area in Sq. Miles (2000)	469	772.09	303	16	579	1,201.89
Persons per Sq. Mile (2000)	7,876.9	682.7	26,402.9	1,565.9	3,371.7	354.8

Land area of the six jurisdictions is likewise quite diverse with the largest jurisdiction being approximately 1,200 square miles (Dane County, WI) to 16 square miles (Aiken, SC). An indication of the extent of urban and rural setting is demonstrated by the persons per square mile, ranging from the most densely populated area with more than 26,400 persons per square mile (New York City) to most sparsely populated jurisdiction of approximately 355 persons per square mile (Dane County, WI).

REACHING THE U.S. FIRE SERVICE WITH HYDROGEN SAFETY INFORMATION: A ROADMAP

EMERGENCY RESPONDER TRAINING NEEDS

Part 3 of 3

A Report for the

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September, 2009

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1) PART 3: INTRODUCTION AND BACKGROUND

The U.S. Department of Energy (DOE) is developing a comprehensive suite of information related to safety in the infrastructure supporting hydrogen energy sources for commercial implementation. The U.S. fire service is an important audience for this information, both as it relates to safety considerations in design and permitting of constructed facilities, and safety considerations related to incident response.

The goal of this project is to improve the transfer of hydrogen safety information to the fire service. The fire service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. This effort will provide an overview of the U.S. fire service and information as to how to communicate with the U.S. fire service in key jurisdictions.

This effort intends to provide a roadmap overview of the U.S. Fire Service, as well as information for facilitating communications with the U.S. Fire Service in key jurisdictions. The infrastructure for decision making and for communication varies from jurisdiction to jurisdiction (state, county, city and region across the country) and by multiple other factors. Working with the multiple jurisdictions is important to help implement the on-going programs required to enable more widespread hydrogen usage.

Three specific tasks comprise the main deliverable of this overall project report, all with a focus on hydrogen-based applications including but not limited to the direct commercial implementation of hydrogen refueling stations and hydrogen back up power installations for telecommunications. The first task (Part 1), involves developing a detailed primer that provides an overview of the Fire Service in the United States. The second task (Part 2) is to generate permitting roadmaps and incident response protocols, supplemented with examples provided by six case study jurisdictions. The third task (this section, i.e. Part 3) is to summarize first responder preferred training needs for applications involving hydrogen-based applications (e.g. road vehicles, rail vehicles, industrial lift trucks, fixed sites, etc).

Specifically, report Part 3 focuses on hydrogen-based applications (e.g. refueling stations, stationary fuel cell power supplies, road vehicles, rail vehicles, industrial lift trucks, etc) and identifies pertinent first responder safety training initiatives and applicable fire service contacts. It additionally reviews approaches for disseminating training information and provides an assessment of fire service training needs.

2) EMERGENCY RESPONSE TRAINING

Today in the United States there are an estimated 1.1 million fire fighters.[1] This estimate is based on a sample survey with a confidence level associated with each estimate, and does not include certain fire fighter constituency groups such as industrial fire departments and federal fire departments.

Approximately three-fourths of these fire fighters serve as volunteers with the remainder serving as career fire fighters. As expected, the more populated jurisdictions are protected primarily by career fire fighters while rural areas are protected primarily by volunteer fire fighters. Some fire departments are a mix of career and volunteer fire fighters in what are considered combination fire departments.

What distinguishes a fire fighter from someone who is not a fire fighter? Most obvious is an individual's formal relationship (e.g. employment or membership) with a recognized fire service organization. Equally important, however, is the individual's education and training to adequately perform the tasks expected of a fire fighter. Another way to describe this education and training is with fire fighter professional qualifications, and these are key to defining the profession. Among the various definitions of "fire fighter" in the common literature, the following reflects the baseline importance of qualification by training and examination:

> *"Fire Fighter: An individual qualified by training and examination to perform activities for the control and suppression of unwanted fires and related events"*[2]

To be "*qualified by training and examination"* are critical defining characteristics for today's fire service. This section covers information on what is typically included in fire service training and education programs, provides an overview of the organizations involved with emergency response training, and reviews approaches for effectively disseminating training materials and information.

Training and Education Programs

Training and education programs help assure that fire fighters are capable of performing the fire fighting tasks to which they respond. The fire service is quasi-military, with the need for potentially large numbers of fire service members to be quickly deployed to handle complicated emergencies. Further, efficient and effective handling of the event is necessary to minimize danger to life and property, which means that there is normally very little time to implement mitigating action.

To adequately address this topic, the following sections will review certain background concepts to clarify the fundamentals of fire service training and education programs. This will

also review the fundamentals of the fire service training infrastructure, with a focus on training initiatives to learn, maintain, and improve the skills required to implement fire service duties. Finally, the approach used to administer the professional qualifications for the fire service will be reviewed.

Background on Fire Service Training

In today's fire service the terms training and education are sometime used synonymously; however, they have different meanings.[3] While both refer to the transfer of information from a body of knowledge to a recipient, each has a different focus on the purpose and details of the information transfer methodology.

Education refers to broad-based learning, with the intent of providing a foundation of general knowledge that supports efficient analytical techniques for effective problem solving. An example is a college degree in business administration, which will provide a fire service officer with the skill set needed to manage a large city fire department. In contrast, training is an exercise in focused learning, and refers to the exchange of specific information intended to enhance the proficiency of a particular skill. An example of training is a fire fighter class that teaches the skills necessary for certification at the "Awareness Level" for a hazardous materials incident. Training is more applicable to emergency events involving hydrogen and similar hazardous materials, and thus training is the primary focus of the information presented herein.

In general, the technical content for fire service training is well-established and addresses a wide range of topics faced by fire fighters. Much of this is captured in the mainstream literature and national standards (e.g. NFPA standards) addressing a wide range of fire fighting tasks, equipment, and other fire service detail. Some of this information has been developed and refined in various arenas for decades.

Specifically, multiple sources of training materials are available that extensively address the topic of hazardous materials. Sources are likewise available that provide useful content on the focused topic of hydrogen, which can be directly and immediately use by members of the fire service and other emergency responders. These training packages address not only the needs of emergency first responders, but also others involved with the safety infrastructure such as permitting officials. As an example, a useful multi-media PowerPoint training package is freely available through the internet from the U.S. Department of Energy that addresses "Hydrogen Safety for First Responders" (see www.hydrogen.energy.gov/firstresponders.html). Similarly, they also provide a PowerPoint training package to assist permitting officials with the implementation of their duties and which is titled "Introduction to Hydrogen for Code Officials" (see www.hydrogen.energy.gov/code_official_training.html).[4, 5]

With regard to standards that set baseline requirements, many of these have been subject to on-going enhancements for decades (as exemplified by documents such as NFPA 1961, *Standard for Fire Hose*, which was first issued in 1898, or NFPA 1410, *Standard on Training for Initial Emergency Scene Operations*, first issued in 1966).[6, 7] In terms of addressing fire fighter

performance, of particular interest is the set of sixteen NFPA standards addressing fire fighter professional qualifications (see Figure 1-11 of Part 1: *Fire Service Primer*). These documents clarify fire fighting disciplines and set required levels of knowledge that can be used for training and other purposes. A summary of examples that illustrate fire fighting disciplines and training levels used by today's fire service is provided in Table 3-1.

Table 3-1: Examples of Fire Fighting Disciplines and Training Levels[8]

FIRE FIGHTING DISCIPLINE	EXAMPLES OF LEVELS	NFPA STANDARD
Airport Fire Fighter		1003
Driver/Operator	Pumper; Aerial, Tiller; ARFF; Mobile Water Supply; Wildland	1002
EMS HazMat	I, II	473
Fire Department Safety Officer	Health/Safety Officer; Incident Safety Officer; ISO-Fire Suppression; ISO – EMS Operations; ISO – HazMat Operations; ; ISO – Special Operations	1521
Fire Fighter	I; II	1001
Fire Inspector	I; II; III; Plans Examiner	1031
Fire Investigator		1033
Fire Officer	I; II; III; IV	1021
Fire Service Instructor	I; II; III	1041
Hazardous Materials	Awareness; Operations; Technician; Incident Commander; Branch Safety Officer; Private Sector Specialist A, B, C; Tech w/Tank Car Specialty, Tech w/Cargo Tank Specialty; Tech w/Intermodal Tank Specialty; Tech w/ Flammable Gases Bulk Storage Specialty; Tech w/ Flammable Liquids Bulk Storage Specialty	472
Industrial Fire Brigade	Incipient; Advanced Exterior; Interior Structural; Advanced Structural; Leader	1081
Marine Fire Fighter	I, II	1005
Public Fire & Life Safety Educator	I; II; III; Public Information Officer; Juvenile Firesetter Intervention Specialist	1035
Public Safety Telecommunicator	I; II	1061
Rescue Technician	Rope; Confined Space; Trench; Structural Collapse; Surface Water; Vehicle & Machinery	1006
Wildland Fire Fighter	I, II	1051

Even with specialized training, fire fighters face a bewildering spectrum of possible emergency events, and thus they are generalists in their core knowledge. They require skills that are already adequately learned and ready to be used before an emergency occurs. Further to the obvious hazards associated with fire ground operations, the duties of a fire fighter include the need for training on additional topics commonly shared with other professions, such as, for example, transportation safety relating to the hazards of large mobile fire apparatus, or bio-hazards associated with the handling of victims with emergency medical related concerns.

Fire service training is a critical part of the activities addressed by fire fighters. This training is of course intended to improve the efficiency of tasks being performed, but on a more personal level, it is not uncommon for a fire fighter to be in a situation where their own personal survival depends on this training. Thus, training is an important part of a fire fighters daily life, and they are continually subjected to learning on a wide range of important topics. For all topics of interest to fire service emergency responders, an on-going need exists for updated, accurate, consistent, readily understandable training information.

This means that the challenges of distributing training information oriented toward certain types of emergencies (i.e. how to handle an incident involving hydrogen) will be similar to the challenges of distributing training information on other topics important to fire fighters. With limited available time from numerous important topics which all compete for this available time, preparing the applicable training information in an efficient and effective manner is important to reach the widest possible audience.

Because of the appreciable range of types of fire fighters and types of fire service organizations, the dissemination of training materials on a specific subject (e.g. handling an incident involving hydrogen) is not necessarily simple and straight-forward. The diverse and dynamic nature of the fire service indicates that a single ideal strategy for effectively disseminating training materials does not obviously exist. Instead, a coordinated multi-faceted strategy tailored to the specific types of fire fighters and types of fire service organizations has the most promise. For example, in certain situations distance learning may be the best option for a wide audience of fire fighters to receive the training they require, while higher levels of knowledge (e.g. operations level versus awareness level) may require more in-depth methods such as hands-on training.

Overview of the Fire Service Training Infrastructure

Fire departments are the basic organizations used by fire fighters to deliver their services. These can range from a small volunteer fire department in rural areas, to large fire departments with all career personnel protecting a major metropolitan city. Training will also depend on the specific hazards within the protected jurisdiction, such as the difference between an industrial district and a bedroom community. Fire departments, regardless of their size or type, have two distinct sources for their training needs: training programs that originate and operate internally within the organization, and those that originate and operate externally.

Figure 3-1 illustrates the two basic sources of training information and materials for the fire service. The extent of internal training sources depends on the available resources of the particular fire department, and as a result, these internal sources tend to be more extensive and sophisticated for larger fire departments (e.g. large city or county fire departments). These larger fire departments generally have their own dedicated training divisions as well as training facilities (i.e. training academy), and are able to effectively handle recruit training and in-service training. Specialized training may be offered for specific duties such as fire apparatus operators, incident commanders, or safety officers. They may also offer specialized courses like those intended for duties beyond the front-line emergency responders, such as fire investigators, fire prevention & inspection personnel (i.e. permitting officials), and public fire & life safety educators.

Multiple external sources of training information and materials are available from a number of sources. These are available to directly support the many fire departments (and especially smaller departments) with limited resources for training. In addition, they also help to supplement and support larger fire departments with their own training departments, and

while doing so promote general consistency throughout the fire service. In some cases, regional training centers fulfill internal training needs despite their external characteristics, and these may be operated at the county or state level, or simply by multiple fire service organizations joining together for this purpose.

Figure 3-1: Types of Training Sources

State governments are a key external resource for fire departments, and many states have designated an official agency to provide state-wide training for fire and emergency personnel. Similarly but at a higher level, the federal government provides important support through the National Fire Academy and other resources. Depending on the legislative and funding arrangements in a particular state or region, certain colleges and universities may serve as centers for fire service training, with or without the involvement of their respective state agency. Supporting all of this is a portfolio of national fire service organizations and private training service organizations that provide valuable components for the fire service training infrastructure.

Of special interest are external sources of training material and information, since this has significant influence on the overall approach and consistency of content used for fire service training. Figure 3-2 provides an overview of fire service training, from the perspective of the external sources that directly influence today's fire service training.

State training agencies and state training directors are central players in the fire service training infrastructure. Training Directors sometimes report to the State Fire Marshal in each state, and many states operate a state-wide training academy. In addition, many also coordinate the training materials and curriculums used throughout the state. In some states fire departments within the state are required to mandatorily use this information and material, and in others they can voluntarily utilize it as they deem appropriate.

Independent public and private training programs that exist within the state often work in coordination with state training programs. These may include the fire service training activities of regional fire districts, large city fire departments, colleges & universities, and other public or private fire service training programs. The relationships among these entities vary significantly from state to state. For example, one state may not have a dedicated state fire training academy and instead have multiple separate but similar training programs throughout the state in conjunction with the state community college system. Elsewhere there may be a state training academy, but the large city fire departments use their own training resources and do not participate in the state programs.

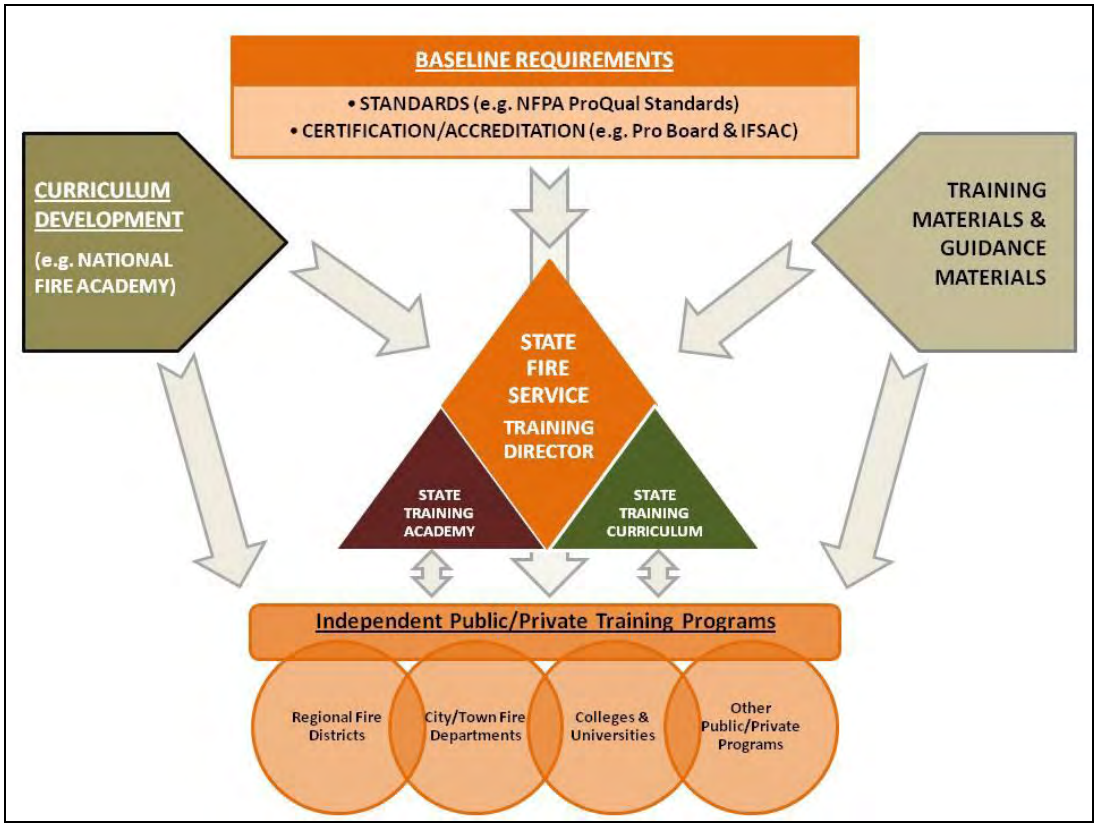

Figure 3-2: Overview of the External Sources of Fire Service Training

On a national level, several key programs, activities and initiatives feed into the multitude of fire service training activities found at the local and state levels. Important baseline requirements are set by the applicable standards that manage the training content and provide a level of agreement on the applicable professional qualifications. These baseline requirements are effectively implemented through accreditation and certification processes.

National organizations such as the National Fire Academy assist with curriculum development and the national promotion of technical training content. A wide assortment of broadly developed training materials and guidance materials also provides direct support. This includes, for example, the training manuals provided by the International Fire Service Training

Association (since 1932), fire service training materials provided by Jones and Bartlett Publishers, and various books and publications provided through Delmar Learning.[9, 10, 11]

Administering Qualifications for the Fire Service

Fire fighting as a profession has been recognized for centuries among various civilizations. It was not until more recently, however, that its professional status has become more distinctly defined, with the development of standardized baseline requirements and the implementation and quality assurance process that supports the use of these requirements.

Starting in 1974, NFPA's professional qualifications standards began to appear, becoming increasingly used by state agencies responsible for fire service training. The use of national standards for fire fighter professional qualifications is a concept that political leaders have been able to naturally embrace, and the appearance of these documents has independently coincided with a general rise in funding and recognition for state fire service training programs.[12]

As a result, most states utilize these standards as the defining measure of professional qualifications for fire fighters. Included in Annex A is a summary of how each state uses these professional qualifications standards.[13] Certification programs in many states are voluntary, and states often do not have mandatory minimum qualifications requirements for fire service personnel.

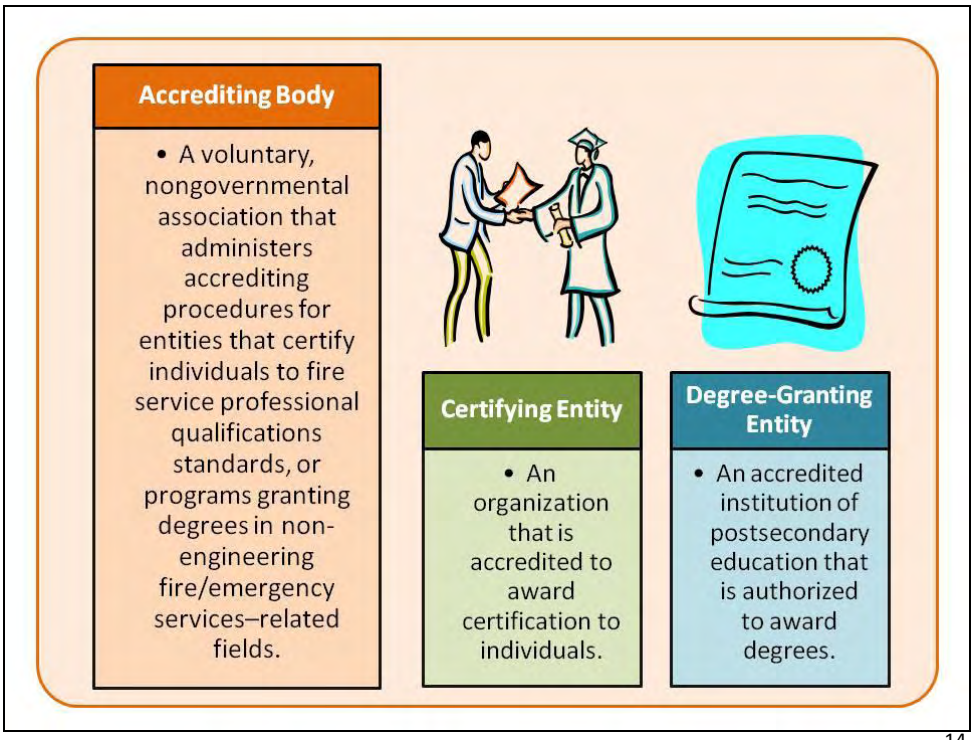

Figure 3-3: Overview of Entities that Accredit, Certify and Grant Degrees[14]

The baseline requirements included in national standards provide a foundation for fire fighter professional qualifications, but how these are consistently implemented and applied is equally important. To achieve this implementation, concepts involving accreditation, certification and degree-granting have evolved. The organizations that administer these concepts are referred to as accrediting bodies, certifying entities, and degree-granting entities, respectively. These are summarized in Figure 3-3, which provides an overview of the entities that accredit, certify and grant-degrees.

As further explanation, accreditation refers to enabling oversight (within a recognized framework that measures and assures quality implementation), bestowed upon another organization. Once accredited, that organization will in turn provide certifications and/or grants degrees to individuals. The following are definitions for accredit, certification, and degree:[15]

> *"Accredit. To give official authorization to or to approve a process or procedure to recognize as conforming to specific criteria, and to recognize an entity as maintaining standards appropriate to the provision of its services."*[16]
>
> *"Certification. An authoritative attestment; specifically, the issuance of a document that states that an individual has demonstrated the knowledge and skills necessary to function in a particular fire service professional field."*[17]
>
> *"Degree. A formal recognition of completion of a prescribed program of study at the postsecondary level."*[18]

Emergency Response Training Organizations

There are multiple organizations involved with training for emergency responders. In the approximate 30,000 individual fire departments in the United States, a pivotal focus for the implementation of training is that which occurs internally within fire department organizations. Supporting these internal training activities are external training sources supported nationally by the federal government, sources coordinated at the state level, and other public and private national sources.

The overall training that individual fire departments experience can vary widely, and be comprehensive and detailed, or conversely, minimal and virtually non-existent. In recent years the annual fire fighter Line of Duty Deaths hovers around the 100 mark, and these are investigated by the National Institute for Occupational Safety and Health (NIOSH).[19] The lessons learned from these fire fighter fatality incidents repeatedly indicate warnings of training that is insufficient, and point to the need for full-service comprehensive training.[20]

Internal Sources of Fire Training

Sources of training that are internal to a particular fire department depend on the available resources of that department. Thus, larger fire departments tend to have more extensive internal training activities. An example (in large fire departments) might be a separate training division that includes a training academy, while in smaller fire departments this may only involve a training officer responsible for coordinating and facilitating the department's training activities.

The most basic form of training need in every emergency response organization is that for new recruits. Fire departments with fewer resources (e.g. remote or rural areas) are more likely to depend on new recruit training that's solely on-the-job, while departments with more resources typically have dedicated classroom and hands-on training and education programs. A structural fire is the same in an urban area or a rural area, and new recruit training is equally important regardless of whether the fire fighters are career or volunteer.

Since most fire fighters will commonly face structural fires, this is a common topic of training that fire fighters generally experience early in their career. The minimum duty requirements for the performance levels for "Fire Fighter I" and "Fire Fighter II", against which new recruits can be measured, are detailed in NFPA 1001, *Standard for the Fire Fighter Professional Qualifications*.[21] As of July 2008, this standard was used as the basis for fire fighter professional qualifications in 42 states and the District of Columbia (see Annex A, Statewide Accreditation Initiatives).

Another approach commonly used to improve fire fighter knowledge and skills is in-service training. This is done by fire fighting crews either in service or temporarily taken out of service during training. In service training takes place with the understanding that any emergency call or superseding administrative task will interrupt the training, which will ultimately be continued at a later time. In-service training is usually economical and efficient; thus it is a regular staple of a fire fighter's daily life. However, its effectiveness can be compromised due to the interruptions that may occur. This training is usually performed at the company level with the company officer providing the instruction.

Certain topics require special internal training on a dedicated and focused topic for all the fire fighters in a fire department. Examples include a review of the operation of newly delivered equipment (such as thermal imaging cameras). In other cases this may address a broader issue of interest to all fire fighters, such as a review and update of information pertaining to the National Incident Command System. Additionally, some training may be applicable to any workplace setting, such as that pertaining to healthy lifestyles or the promotion of workplace diversity.

In addition to baseline training to which all fire fighters receive sometime during their career, specialized internal training may focus on specific fire service job assignments. Fire departments perform additional tasks other than responding to emergencies and directly mitigating them to a manageable level, such as: fire prevention & inspection; fire investigations; public fire & life safety education; and vehicle maintenance.

Understandably, certain internal training programs are often focused toward these additional fire service functions. Some of these other functions require the fire service staff to have appreciable skills to perform their duties. For example, fire inspectors that work under the Fire Marshal require the necessary training on the applicable codes and permitting process for their jurisdiction. If a fire inspector fails to do his or her job properly it could result in either an unsafe condition for building occupants and responding fire fighters, or overly restrictive requirements that are inefficient and unnecessary for the building owner.

Training for fire department officers is a segment of an overall training program worth special attention. Fire officers have the added responsibility for the safety of the fire fighters operating under their command. The decisions of incident commanders and company officers on the fire ground can sometimes mean the difference between life or death. Attaining the rank of a fire officer requires demonstrated competency, knowledge and leadership skills, and training is an important part of their professional development.

Another extension of internal training beyond courses intended for all fire fighters, is training for special operations. Most jurisdictions will encounter emergencies (other than structural fires) that require highly trained fire fighters for handling the event. For example, hazardous materials' training is generally considered as one area of special operations training.[22] Another distinct topic area involves technical rescue, which includes focused sub-topics such as confined space entry, trench rescue, high angle rescue, underwater and under-ice operations, structural collapse, and so on.[23]

Federal Fire Training Sources

Certain agencies within the U.S. federal government have extensive involvement with the training of emergency responders. Some agencies and departments have extensive fire fighting resources themselves, such as the Department of Defense or the Forest Service; like other fire departments, they of course also require on-going training. But in addition, certain federal agencies are directly involved with the development, upkeep and dissemination of training materials in support of emergency first responders.

Foremost among these federal organizations involved with and helping to support fire service training and education is the *Federal Emergency Management Agency (FEMA)* of the *U.S. Department of Homeland Security (DHS)*.[24] Specifically, several important initiatives and programs are administered through the *United States Fire Administration (USFA)* that reports to FEMA.[25]

Among the short list of key federal government organizations serving as external training sources, one organization at the top of this list is the *National Fire Academy (NFA)* of the USFA.[26] The NFA is the Fire Administration's training delivery arm and is located in Emmitsburg, Maryland. The creation of the NFA has its genesis in the landmark report "America Burning" written in 1973, which recommended the establishment of a "National Fire Academy for the

advanced education of fire service officers and for assistance to state and local training programs".[27]

With more than three decades of operation, the NFA has earned the respect of the fire service and provides an important stabilizing influence that helps to unite the fire service on the myriad of specific training topics. As a central focus point for the development and refining of fire service training materials, the NFA works closely with not only the vast range of local and regional fire departments throughout the country, but equally with the various national organizations that administer important sub-components of the training infrastructure. At the state level the NFA works closely with the North American Fire Training Directors.

The NFA provides an important forum for the centralized development, refinement and dissemination of fire service training materials on specific topics. Aside from the actual training courses delivered on-site at the NFA, another means available to build special topic curricula which are then made available for internal fire department training activities is through NFA "Endorsed Courses".[28] The NFA also provides hand-off training programs for individual training academies that are usually based on 2 days worth of content.

These Endorsed Courses at NFA provide a mechanism for outside interested organizations to cultivate and promote the development of applicable, state-of-the-art, accurate, useful and timely training information. As a specific example worthy of consideration, the training information contained in U.S. DOE on-line training packages such as "Hydrogen Safety for First Responders" and "Introduction to Hydrogen for Code Officials" may be candidates for material used in NFA endorsed courses.[29, 30]

One NFA activity that serves a critical role in disseminating training information to the various state and local training agencies is the *Training Resources and Data Exchange (TRADE)* program.[31] This is a network of the state fire service training systems, along with the senior executive training officers from the Nation's largest fire departments protecting populations greater than 200,000 and/or who have more than 400 uniformed personnel. As a regionally based network established in 1984, TRADE facilitates the exchange of fire-related training information and resources among government organizations at the local, state and federal levels.

The TRADE system operates using geographic regions that correspond to the ten FEMA regions, with coordinated networking within the respective regions and between regions. The National Fire Academy works closely with TRADE on various training details, and refers to them for functions such as the review of NFA Endorsed Courses. Specifically, TRADE serves their mission through the following:

- Identifying regional fire, rescue, and emergency medical services training needs;
- Identifying applicable fire-related training and education national trends;
- Exchanging and replicating training programs and resources within Regions; and
- Provide annual regional assessments of fire training resource needs to NFA.

FEMA and other agencies within DHS also have a focus toward training emergency responders, especially as it relates to large scale disasters that may require extensive mutual aid to deploy the necessary resources. Many of the FEMA programs are coordinated through the ten FEMA regions throughout the United States (see Table 3-2). Additional training resources operating under FEMA and DHS to address the national training interests of all emergency first responders include the National Training Program (NTP), Center for Domestic Preparedness (CDP), Emergency Management Institute (EMI), and Training & Exercise Integration/ Training Operations (TEI/TO).

One such program administered by FEMA is the *National Training Program (NTP)*. The purpose of NTP is to provide an organized approach to training for emergency managers and emergency response providers throughout the United States. This is based on National Preparedness Guidelines provided and administered by DHS. NTP programs address training design, development, delivery, and evaluation, and their programs attempt to utilize national voluntary consensus standards for training as appropriate.[32]

Table 3-2: FEMA Regions for States and Territories

FEMA REGION	STATES
I	Connecticut; Maine; Massachusetts; New Hampshire; Rhode Island; Vermont
II	New Jersey; New York; Puerto Rico; Virgin Islands
III	Delaware; District of Columbia; Maryland; Pennsylvania; Virginia; West Virginia
IV	Alabama; Florida; Georgia; Kentucky; Mississippi; North Carolina; South Carolina; Tennessee
V	Illinois; Indiana; Michigan; Minnesota; Ohio; Wisconsin
VI	Arkansas; Louisiana; New Mexico; Oklahoma; Texas
VII	Iowa; Kansas; Missouri; Nebraska
VII	Colorado; Montana; North Dakota; South Dakota; Utah; Wyoming
IX	American Samoa; Arizona; California; Guam; Hawaii; Mariana &; Marshall Islands; Micronesia; Nevada; Palau
X	Alaska; Idaho; Oregon; Washington

The *Emergency Management Institute (EMI)* operates through FEMA, and is the national focal point for the development and delivery of emergency management training.[33] Its purpose is to enhance the capabilities of federal, state, local, and tribal government officials, volunteer organizations, and the public and private sectors. EMI programs are implemented consistent with the overall goal of minimizing the impact of disasters.

Another initiative under the DHS umbrella for the broad emergency response community is the *Center for Domestic Preparedness (CDP)*. The CDP, located in Anniston, Alabama is the only federally chartered training center dealing with weapons of mass destruction (WMD).[34] CDP has a reputation for a high level of knowledge and expertise for addressing emergencies involving special and exotic materials. Not surprisingly, hazardous materials are a natural component of the subject matter they address.

The *Training & Exercise Integration/ Training Operations (TEI/TO)* is a training program that operates under the *National Integration Center (NIC)*, which is administered by FEMA's National Preparedness Directorate.[35] The National Preparedness Directorate was established as a result of the Post-Katrina Emergency Management Reform Act (PKEMRA) that merged the DHS

Preparedness Directorate with FEMA. Soon after, NIC was established to handle the consolidation of the legacy training activities from these government organizations. Included among these legacy training activities is the Department of Justice Office of Domestic Preparedness, established in 1998.

TEI/TO offers more than 125 courses to the first responder community to help build critical skills needed for the effective handling of mass consequence events.[36] They focus on multiple professional disciplines (including the fire service) and also address domestic preparedness involving the private sector and local citizens. TEI/TO works in conjunction with multiple other partner training organizations; they oversee the Competitive Training Grants Program (CTGP) that awards funds for the development and delivery of innovative training programs addressing high priority national homeland security training needs.

Another way that FEMA directly assists emergency responders is by direct funding to implement internal training programs. The Assistance to Firefighters Grant (AFG) program, also referred to as "Fire Grants", helps firefighters and other first responders obtain training, equipment, vehicles and other resources needed to protect the public and emergency personnel from fire and related hazards.[37]

The Fire Grants program is administered by FEMA through their division on Grant Programs. As an indication of the level of activity in this FEMA program, in 2009 19,791 applications requested more than $3.1 billion in AFG grants.[38] A related FEMA funding initiative is the SAFER (Staffing for Adequate Fire and Emergency Response) program, although this is less focused on training and instead provides funding directly to fire departments and volunteer firefighter interest organizations to help them increase the number of "trained" front-line firefighters for their respective community.[39]

Another federal government department that is an active source of training information for emergency responders is the *Department of Transportation (DOT)*. Among their various useful programs, DOT provides direct resource support on specific topics like hydrogen safety with on-line information dedicated to the topic through their website hydrogen.dot.gov/.[40]

An agency within DOT, the *Pipeline and Hazardous Materials Safety Administration (PHMSA)* supports and maintains the "Emergency Response Guidebook" (ERG), which is an essential document for fire service emergency responders. The ERG circulation is very widespread among fire service emergency first responders throughout North America, since printed copies are freely distributed by the federal governments of Canada, Mexico and the United States.[41] The ERG contains important details on hazardous materials (such as hydrogen) and places this information at the fingertips of emergency first responders. It would be unusual for a U.S. fire department first on the scene of an emergency not to have a copy of the ERG in either book or electronic format.

In addition, the DOT's PHMSA also sponsors a regional training initiative in collaboration with the International Association of Fire Chiefs (IAFC) known as the *National Hazmat Fusion*

Center.[42] Through the use of a secure on-line information portal, the center provides important knowledge for emergency responders on the transportation and delivery of hazardous materials. Through information collection, analysis, and dissemination, the web portal is intended to enhance tactics, operations, policy and training for first responders handling hazardous materials incidents.

The *Department of Energy (DOE)* has several emergency responder training resources that they have developed to support their efforts to promote the on-going safe use of certain forms of alternative energy. Several of these have direct applicability to the use of hydrogen. Of particular note is the DOE "*Volpentest HAMMER Training and Education Center*" located in Richland, WA at the DOE Hanford Site. The term "HAMMER" represents the acronym for Hazardous Materials Management and Emergency Response.[43]

The HAMMER facility combines more hazardous materials and emergency response training facilities than any other U.S. complex, and it serves the training needs for workers and emergency responders from numerous federal, state, county and city agencies. It has unique hands-on training resources dedicated to hydrogen and related topics. The HAMMER site is operated by a partnership of federal agencies with DOE as the lead managing agency; the others include the: FEMA, DOT, U.S. Environmental Protection Agency (EPA), and Occupational Safety and Health Administration (OSHA). Other non-government partners also work closely as collaborating partners with the site, including international labor unions, and certain regional tribal governments.

In addition to the HAMMER facility, DOE provides extensive on-line information relating to hydrogen and safety related topics for emergency responders. Some of this information is expressly designed as informative training packages specifically for emergency responders and other safety officials. For example, two on-line training packages currently available are "Hydrogen Safety for First Responders" and "Introduction to Hydrogen for Code Officials" through the hydrogen.energy.gov web portal.[44, 45]

Additional federal departments and agencies develop information that ultimately feed into emergency response training programs. Close examination reveals a significant range of departments and agencies that have a less direct yet important supporting role in the development of fire service training materials. Several examples for purposes of illustration are:

- Statistical data from the Consumer Product Safety Commission (CPSC);
- Recommendations on safe handling of hazardous materials via the Chemical Safety Board (CSB);
- Guidance for environmental clean-up via the Environmental Protection Agency (EPA);
- Fire fighter line of duty death investigation reports from the National Institute for Occupational Safety and Health (NIOSH);
- Research studies from the National Institute for Standards & Technology (NIST);

- Transportation investigative reports from the National Transportation Safety Board (NTSB); and
- Summaries of workplace hazards per the Occupational Health & Safety Administration (OSHA).

State Fire Training Sources

All states have a point of contact for their fire service training activities, and most have a designated official state agency to either provide or to coordinate training for fire and other emergency responders throughout the state. Table 3-3 summarizes the agency contacts for fire service training in each state.

State level coordination of training curricula and training facilities is common, and one approach is to encourage fire department participation on a voluntary basis. In some states, however, fire service training is mandatory through state labor programs or other legislation, and the state agency responsible for fire service training offers a valuable resource toward fulfilling these obligations. For example, the Washington State Department of Labor and Industries enforces the Washington Industrial Safety and Health Act, which requires fire fighter training commensurate with those duties and functions expected to be performed.[46]

Table 3-3: Agency Contacts for State Fire Service Training

STATE	TRAINING ACADEMY/DIVISION	WEBSITE
Alabama	Alabama Fire College and Personnel Standards Commission	*www.alabamafirecollege.org*
Alaska	Division of Fire & Life Safety Training and Education	*www.dps.state.ak.us/Fire*
Arizona	State Fire Training Director, Office of the State Fire Marshal	*www.dfbls.az.gov/ofm/firetraining.aspx*
Arkansas	Arkansas Fire Academy/SAU-Tech	*www.sautech.edu/afta*
California	CA Dept. of Forestry & Fire Protection, Office of State Fire	*www.osfm.fire.ca.gov/training/training.php*
Colorado	Colorado Department of Public Safety, Division of Fire Safety	*dfs.state.co.us*
Connecticut	Connecticut Fire Academy	*www.ct.gov/cfpc/site/default.asp*
Delaware	Delaware State Fire School	*statefireschool.delaware.gov*
Florida	Div of State Fire Marshal, Bureau of Fire Standards & Training	*www.fldfs.com/sfm/bfst/bfst_index.htm*
Georgia	Georgia Fire Academy	*www.gpstc.org/divisions/gfa/index.html*
Hawaii	Hawaii State Fire Council	*dlir.state.hi.us/labor/sfc/index.shtml*
Idaho	Emerg Services Training, ID Div. of Professional-Tech. Ed.	*www.pte.idaho.gov/EmergencyServicesTraining/Home.htm*
Illinois	University of Illinois, Fire Service Institute	*www.fsi.illinois.edu*
Indiana	Indiana Department of Homeland Security	*www.in.gov/dhs/2427.htm*
Iowa	Fire Service Training Bureau	*www.dps.state.ia.us/fm/fstb/*
Kansas	Kansas Fire & Rescue Training Institute	*www.continuinged.ku.edu/fire/*
Kentucky	Fire/Rescue Training Program	*legacy.kctcs.edu/kyfirecommission/*
Louisiana	LSU Fire & Emergency Training Institute	*feti.lsu.edu/*
Maine	Southern ME Community College, Maine Fire Training & Ed.	*www.mfte.org/*
Maryland	Maryland Fire and Rescue Institute	*www.mfri.org/*
Massachusetts	Massachusetts Firefighting Academy	*www.mass.gov/*
Michigan	Office of Fire Fighter Training	*www.michigan.gov*
Minnesota	MN State Colleges and Universities, Fire/EMS/Safety Center	*www.firecenter.mnscu.edu/*
Mississippi	MS State Fire Academy	*www.mid.state.ms.us/fireacad/*

Missouri	**Fire & Rescue Training Institute, University of Missouri**	*www.mufrti.org/*
Montana	**MSU Fire Training School**	*www.montana.edu/wwwfire/*
Nebraska	**State Fire Marshal's Office, Training Division**	*www.nebraskasfmtd.org/*
Nevada	**Fire & HazMat Training & Cert., Nevada State Fire Marshal Div.**	*fire.state.nv.us/Training.shtml*
New Hampshire	**NH Div. of Fire Standards & Training and Emerg Med. Services**	*www.nh.gov/safety/divisions/fstems/*
New Jersey	**Office of Training & Certification, Division of Fire Safety**	*www.state.nj.us/dca/dfs/bfds.htm*
New Mexico	**NM Firefighters Training Academy**	*www.nmprc.state.nm.us/fta.htm*
New York	**NY State Dept of State, Office of Fire Prevention & Control**	*www.dos.state.ny.us/fire/training.htm*
North Carolina	**Deputy Comm of Insurance, NC Fire & Rescue Services Div.**	*www.ncdoi.com/OSFM/FireAndRescueCommission/FR_home/*
North Dakota	**North Dakota Firefighter's Association**	*ndfa.net/fireschool_09.htm*
Ohio	**Ohio Fire Academy, Division of State Fire Marshal**	*www.com.ohio.gov/fire/fmacMain.aspx*
Oklahoma	**Fire Service Training, Oklahoma State University**	*www.osufst.org/*
Oregon	**Dept. of Public Safety Stand's & Training, Oregon Public Safety**	*www.oregon.gov/DPSST/index.shtml*
Pennsylvania	**PA State Fire Academy, Office of the State Fire Commissioner**	*www.osfc.state.pa.us/osfc/site/default.asp*
Rhode Island	**Rhode Island State Fire Academy**	*www.fire-marshal.ri.gov/academy.php*
South Carolina	**South Carolina Fire Academy**	*www.scfa.state.sc.us/*
South Dakota	**SD Dept of Public Safety**	*www.state.sd.us/dps/fire/Training.htm*
Tennessee	**TN Fire Service & Codes Enforcement Academy**	*tn.gov/commerce//sfm/tfaca/index.shtml*
Texas	**TX Engineering Extension Service, Texas A&M University Sys.**	*teexweb.tamu.edu/*
Utah	**Utah Fire and Rescue Academy**	*www.uvu.edu/ufra/*
Vermont	**Vermont Fire Academy**	*www.dps.state.vt.us/fire/vfstc/index.html*
Virginia	**Virginia Department of Fire Programs**	*www.vafire.com/*
Washington	**Washington State Patrol**	*www.wsp.wa.gov/fire/firemars.htm*
West Virginia	**West Virginia University Fire Service Extension**	*www.wvu.edu/~exten/depts/fireserv/fireserv.htm*
Wisconsin	**Wisconsin Technical College System**	*www.wtcsystem.edu/*
Wyoming	**Fire Prevention & Electrical Safety**	*wyofire.state.wy.us/training/index.html*

An organization that serves a key coordinating role at the state level is the *North American Fire Training Directors (NAFTD)*.[47] The NAFTD promotes the common interests of providing quality fire training and education for the fire service; its membership is comprised of State Fire Training Directors of each of the fifty United States and all Canadian provinces and territories. To be effective, efforts involving the dissemination of fire service training information should consider NAFTD and their role as an important gateway into the fire service training network.

NAFTD members serve as the primary point of contact for fire training and education conducted in their jurisdiction (i.e. state, province or territory), and are typically based in a state government entity such as the state fire marshal's office or state fire commission, or through a college or university. Fire fighter training is provided each year through the NAFTD member organizations to over 800,000 members of the fire service. In addition to coordinating and delivering their own training programs, NAFTD members works in concert with the National Fire Academy (NFA) as their representatives in each state. For example, NAFTD works collaboratively with the NFA in their TRADE (Training Resources and Data Exchange) program.

An important networking resource that operates at the state level and provides specific information on hydrogen safety is the *Hydrogen Executive Leadership Panel (HELP)*.[48] This program, which is administered by the National Association of State Fire Marshals (NASFM), is a

three way joint initiative of: NASFM; the Research and Innovative Technologies Administration of the U.S. Department of Transportation; and the International Consortium for Fire Safety, Health and the Environment (an independent international organization formed in 2001 by environmental, health and fire safety regulatory officials and scientists).[49] HELP focuses on bringing stakeholders together to facilitate a safe and orderly transition from fossil to hydrogen fuels, and it facilitates useful networking on this topic and assists with training information.

Other Fire Training Sources

Many national based organizations provide a key role in the development and dissemination of fire service training materials. is the following examples are not intended to be an exhaustive list, but is intended only for purposes of illustration. These external training sources are in addition to the state and federal sources already discussed, and for convenience they are grouped by those providing: (1) professional qualification requirements, (2) training material development, and (3) centers of professional development such as colleges & universities.

(1) Professional Qualification Requirements. There are several groups that have an important role with the development and implementation of baseline requirements for professional qualifications for fire fighters. Several organizations of note are:

Center for Public Safety Excellence (CPSE)

The CPSE establishes and promotes recognized professional standards to help fire agencies move beyond tactical deployment to continuous strategic improvement. The origins of CPSE can be traced back to 1986 when the International Association of Fire Chiefs and the International City-County Management Association met to develop the concepts and design for continuous improvement of the fire service. In 1996 the Commission on Fire Accreditation International was established, and in 2001 this was incorporated as a non-profit corporation under the current title of the Center for Public Safety Excellence. The Center oversees two commissions: the Commission on Fire Accreditation International (CFAI) and the Commission on Professional Credentialing (CPC).[50]

International Fire Service Accreditation Congress (IFSAC)

IFSAC is a nonprofit organization that functions as a part of the College of Engineering, Architecture and Technology at Oklahoma State University, located in Stillwater, Oklahoma. They operate according to a self-governing peer-driven process that accredits both fire service certification programs and higher education fire-related degree programs.[51]

National Fire Protection Association (NFPA)

The NFPA is the custodian organization for the development and maintenance of the multiple fire service standards providing the basis for the performance levels that qualify the fire fighting profession (i.e. the professional qualification standards, among others). The codes and standards that come from NFPA utilize a full consensus process accredited by the American National Standards Institute (ANSI), and these regularly updated documents have wide involvement from the fire service stakeholder community. Founded in 1896, NFPA is a non-profit membership association with approximately 75,000 members, and operates with a mission to make the world safer from fire and related hazards.[52]

National Board on Fire Service Professional Qualifications (Pro Board)

The National Board on Fire Service Professional Qualifications, more commonly known as Pro Board, was incorporated in 1990 as a non-profit corporation to establish an internationally recognized means of acknowledging professional achievement in the fire service and related fields. This is accomplished through the accreditation of organizations that certify uniformed members of public fire departments, and certain other qualifying organizations who certify individuals with allied emergency response and fire protection interests. Governance of Pro Board is provided through representatives from the International Association of Arson Investigators (IAAI), the International Association of Fire Chiefs (IAFC), the National Association of State Fire Marshals (NASFM), the National Fire Protection Association (NFPA), and the North American Fire Training Directors (NAFTD).[53]

Networks of multiple private organizations provide a foundation of supporting services for the implementation of these baseline professional qualification requirements. These have evolved to serve the needs of fire departments and others who look for turn-key implementation of these programs. For example, organizations provide private or regional training seminars, as well as testing services for the measurement of candidates subjected to the training.[54]

(2) Training Material Development. There is a wide spectrum of public and private organizations involved with the development of training materials for emergency responders. Some of these groups provide actual training curriculums and materials, others provide full training programs, and still others provide specific information that is used directly in training programs. The following are several diverse examples of organizations, programs and activities providing these resources:

Chemical Transportation Emergency Center (CHEMTREC®)

The genesis of CHEMTREC can be traced back to the World War I era, but the organization as we know it today was established in 1970 by the chemical industry in cooperation with the U.S. Department of Transportation.[55] Operated by the American Chemistry Council, a key service provided by CHEMTREC is a toll-free telephone number staffed around the clock as a public service hotline for emergency responders to obtain information and assistance for emergency incidents involving chemicals and hazardous materials. Hazardous materials shippers also register with CHEMTREC which assists them in complying with the DOT hazardous materials regulations that require them to provide a 24-hour emergency telephone number on shipping documents. CHEMTREC also holds domestic and international workshops relating to information exchange involving hazardous materials, helping to clarify its role for emergency responders as a premier source of timely hazardous materials information.

Fire Department Instructors Conference (FDIC)

FDIC is a trade show devoted entirely to fire service training, and is held annually for a week in late April in Indianapolis Indiana. The 2009 conference had an estimated 28,000 fire fighters in attendance, and is administered by Pennwell Publishing.[56] An extensive trade exhibit accompanies the multiple workshops and seminars held throughout the conference.

International Fire Service Training Association (IFSTA)

The mission of IFSTA is to identify areas of need for training materials and foster the

development and validation of training materials for the fire service and related areas. With origins that are traced back to 1934, this association of fire service personnel provides oversight and validation of the manuals, curricula, training videos, CD-ROMs, and other materials developed by Fire Protection Publications (FPP). FPP is a department of Oklahoma State University and serves as the headquarters for IFSTA in Stillwater, Oklahoma.[57]

International Hazardous Materials Response Teams Conference (IHMRTC)

The IHMRTC is an annual conference sponsored by the Hazardous Materials Committee of the International Association of Fire Chiefs, and is also referred to as the IAFC HazMat Conference. The event is generally held each May in the Baltimore metropolitan area and is one of the nation's leading events for hazardous materials professionals covering all aspects of working with hazardous materials. Multiple workshops and seminars held throughout the conference support the development and dissemination of training materials.[58]

International Society of Fire Service Instructors (ISFSI)

The ISFSI is a private membership association to provide networking opportunities and resources for fire service instructors. Membership includes fire service personnel of all ranks and from all types of departments. The Fire Department Instructors Conference held annually in April in Indianapolis Indiana is the home conference for the ISFSI membership.[59]

Jones and Bartlett Publishing (J&B)

J&B publishes an extensive line of training materials for the fire service, including comprehensive online resources for fire service students and instructors. As an independent publisher headquartered in Sudbury MA, they are the seventh largest college publisher in the United States, publishing training materials as professional and reference books as well as a variety of multimedia and online products. The content for their training materials is developed in collaboration with the International Association of Fire Chiefs and the National Fire Protection Association.[60]

Transportation Community Awareness and Emergency Response (TRANSCAER®)

TRANSCAER is an example of an existing program that that effectively distributes hazmat training materials to fire service emergency responders. This entails a voluntary national outreach effort to directly assist communities with preparation and response for possible hazardous material transportation incidents. TRANSCAER was founded in 1986, and through support of the American Chemistry Council, its industry and government membership provide outreach to assist communities that do not host a major chemical facility but do host major transportation routes.[61] Specifically, this outreach includes the National TRANSCAER Task Group that manages the training program, and regional and state TRANSCAER coordinators who locally implement the program in one of five regions across the United States.

In addition to organizations that develop information and materials used for training, there are existing programs on certain subjects that offer helpful models for possible approaches to convey topic specific information (e.g. hydrogen) to emergency responders. For example, one program that has established itself among fire service professionals as a center for training information on a specific topic is the *Ethanol Emergency Response Coalition (EERC)*. The EERC is a membership organization that addresses safety concerns with the transport and handling of

ethanol and ethanol blended fuels, and they focus on improving the operational readiness of emergency response agencies.[62] The EERC provides detailed on-line training information in multiple formats.

(3) Centers of Professional Development. Institutions of higher education are an important component in the landscape of training fire fighters and other emergency responders. Every state is different in how they utilize and work with their local colleges and universities.

In some states, in lieu of a state fire training academy, the state fire training program coordinates with one or more colleges and/or universities, either at a single location or at regional locations throughout the state such as through a community college system. In some states they supplement a state fire training academy, and in a few instances their programs are so large that they handle not only the fire fighters in their host state, but also those from other states as well.

Following are three examples of state fire fighter training organizations affiliated with institutions of higher education. Each has established a reputation for providing fire service training to thousands of emergency responders in their state and beyond:

Illinois Fire Service Institute (IFSI)

The IFSI is affiliated with the University of Illinois at Urbana - Champaign, and is the statutory fire academy for the State of Illinois. In 2007 it processed 55,000 students from Illinois and other states at the Champaign facility, and through local training programs at almost 350 training and fire department locations throughout the state.[63]

Maryland Fire and Rescue Institute (MFRI)

For more than 75 years MFRI has served the needs of the fire service in the State of Maryland, and today they operate in the University of Maryland system.[64] MFRI serves as the State's fire and emergency service training agency. With over to 8,000 certifications provided to fire fighters in 2008, they provide comprehensive training and education for the state's emergency response services.[65] Like other large training and education programs, they attract and process emergency response personnel from states other than their host state of Maryland.

Texas Engineering Extension Service (TEEX)

TEEX belongs to the Texas A&M University System; for more than 80 years they have provided training for fire service and other emergency responders. In 2008 they processed more than 200,000 students with participants from all 50 states and multiple countries.[66] With headquarters located in College Station Texas, they also offer training at local and regional locations. TEEX is also home to the National Emergency Response and Rescue Training Center (NERRTC) on behalf of the U.S. Department of Homeland Security, and provides WMD (weapons of mass destruction) training and exercises to prepare emergency responders for terrorist attacks.[67]

Training Program Implementation

The establishment of state-of the art information on a training subject is an important step for emergency response training, but the effective delivery of this information is equally important. The communication and delivery of training materials is a fundamental part of the overall training system.

General Concepts Relating to Training and Education

A fire service training director is key to the implementation of fire service training. This is a recognized position similar to other specific jobs performed by fire fighters; they operate according to baseline requirements set by NFPA 1041, *Standard for Fire Service Instructor Professional Qualifications*.[68] NFPA 1041 defines three levels of fire service training instructors as follows:[69]

> *"Instructor I: A fire service instructor who has demonstrated the knowledge and ability to deliver instruction effectively from a prepared lesson plan, including instructional aids and evaluation instruments; adapt lesson plans to the unique requirements of the students and authority having jurisdiction; organize the learning environment so that learning is maximized; and meet the record-keeping requirements of authority having jurisdiction."*
>
> *"Instructor II: A fire service instructor who, in addition to meeting Instructor I qualifications, has demonstrated the knowledge and ability to develop individual lesson plans for a specific topic including learning objectives, instructional aids, and evaluation instruments; schedule training sessions based on overall training plan of authority having jurisdiction; and supervise and coordinate the activities of other instructors."*
>
> *"Instructor III: A fire service instructor who, in addition to meeting Instructor II qualifications, has demonstrated the knowledge and ability to develop comprehensive training curricula and programs for use by single or multiple organizations; conduct organization needs analysis; and develop training goals and implementation strategies."*

Well-developed training material that is effectively delivered will have a lasting effect on those who receive it. Sustainability of communicated knowledge is paramount to successful training, and the lasting impression of the training information on the trainee is an important objective of the training process.

Providing quality instruction requires consideration of four basic sub-topics.[70] First are the basics of instructional delivery, which include a fundamental understanding of the learning process and appreciation for the different approaches available for instruction. Second, practical application skills such as the instructor communication, lesson plans, learning environment, and presentation media are an important consideration. Third are the methods of evaluation and testing, not only for the trainees but also for the instructors. Fourth is the on-going management of the overall training program to continually deliver timely, useful and accurate training information.

The information presented to fire fighters must be well understood and remembered so that it can subsequently be effectively used during stressful fire ground operations. How information is presented can significantly impact how well a person will ultimately understand and be able to recall this information. Every fire fighter in every fire department is unique in terms of how they learn best.

In the field of education, much attention has been devoted to better understanding the learning process and optimum methods for communicating knowledge. For example, one concept that is often used to help fire service instructors and other educators to better appreciate learning styles are the so-called "laws of learning".[71]

In the 1930s educational psychologist Edward Thorndike was credited with establishing the framework for the laws of learning when he proposed the following three: readiness, exercise, and effect.[72] In the years that followed three additional laws have been added: primacy, recency, and intensity. These six laws are suitable for most learning situations and address the following:[73]

> *Law of Readiness. A person learns best when he has the necessary background, a good attitude, and is ready to learn.*
>
> *Law of Exercise. Those things most often repeated are the best learned (providing the basis for practice and drills).*
>
> *Law of Effect. Learning is stronger when joined with a pleasing or satisfying feeling. It is weakened when linked with an unpleasant feeling.*
>
> *Law of Primacy. The first experience of a student should be positive and provide a stable foundation for all that follows.*
>
> *Law of Recency. Other things being equal, the things learned last will be best remembered.*
>
> *Law of Intensity. A sharp, clear, or exciting learning experience teaches more than a routine or boring one.*

Examples of Fire Service Training Initiatives

To provide additional focus on fire service training initiatives, the training programs utilized for six case study jurisdictions are offered for review. This is intended to exemplify the diverse nature of the training processes that are currently in place for the fire service in the United States. The wide spectrum of different fire fighter and fire departments in unique geographic settings necessitate a range of approaches and methods for handling training activities.

The optimum arrangement will vary depending on multiple factors subject to on-going change. For example, this might include the size and type of fire department, characteristics and job

function of the fire fighter trainee, special characteristics of the local geographic region, available resources at the county or state level, private training and education providers in the area, and so on. The training activities of the following jurisdictions are included in this review: Los Angeles, California; Jefferson County, Colorado; New York City, New York; Aiken, South Carolina; Houston, Texas; and Dane County, Wisconsin.

Los Angeles, California.

The City of Los Angeles Fire Department (LAFD), like other large city fire departments in the United States, coordinates their primary training activities through an internal training division. The main training facility is the Frank Hotchkin Memorial Training Center; it operates using two division sections that focuses on in-service training and recruit training.[74] New recruits also attend training through an additional facility located at Valley Training Academy at Drill Tower 89.[75]

While the LAFD does not utilize use the state resources for fundamental fire fighter training, it participates alongside other jurisdictions in various programs related to state oriented emergency management planning (e.g. focusing on multi-jurisdiction events such as wildfire, earthquakes, etc). Although the state of California does not have a State Fire Academy in the same way as other states, the state fire agency CAL FIRE has its own fire academy and this is utilized by fire departments throughout the state that do not have their own programs.

The State Fire Marshal's Office is actively involved in statewide fire fighter training by coordinating the certification and validation of curricula and instructors throughout the state for all California fire fighters. California utilizes the IFSAC process for its accreditation, and currently does not offer reciprocity for certifications obtained from outside of California.[76] The California Office of State Fire Marshal also provides special training resources; they are planning to debut a training package specifically focused on hydrogen training in late 2009.[77]

Jefferson County, Colorado

In Colorado the incorporated districts are responsible for their own fire service training, although the state has a State Training Academy that serves the needs of rural and unincorporated areas. The Colorado Fire Fighters Academy was initiated in early 1986 is a consolidated effort between the San Juan Basin Technical College, 11 emergency service agencies in southwest Colorado, the Colorado Division of Fire Safety, and the Colorado State Fire Chiefs Association. The academy focuses on providing quality training and education in a rural setting for all levels of the fire service.[78]

At the state level Colorado uses both the IFSAC and Pro Board accreditation processes, and they recognize conditional reciprocity from certifications outside the state. The Colorado Division of Fire Safety utilizes multiple NFPA professional qualification standards as the basis for defining the job performance requirements for Colorado fire fighters.[79]

The incorporated jurisdictions within Jefferson County provide their own training. For example, the West Metro Fire Protection District coordinates their training and education programs with

several surrounding jurisdictions and fire districts, including South Metro Fire Rescue, Platte Canyon Fire Department, Littleton Fire Rescue, Fairmount Fire Protection District, and West Metro Wildland Team.[80] The West Metro Fire Protection District is currently finalizing the construction of a new training center and training site (at their station 10).

New York City, New York

As one of the largest fire departments in the world, the New York City Fire Department (FDNY) is like other large metropolitan fire departments in that it has extensive internal training and education programs. These operate primarily through the Bureau of Training and the FDNY Fire Academy located on Randall's Island between the boroughs of Manhattan, Queens and the Bronx. This includes a section that focuses extensively on hazardous materials.[81]

The FDNY Bureau of Training was established in 1869 and moved into the Randall's Island facility in 1975. They are responsible for the initial training and continuing skills development for all FDNY fire fighters, fire officers and emergency medical service personnel. Based on 2008 statistics, this includes training responsibilities for FDNY's 11,275 uniformed fire personnel and their 3,071 uniformed EMS providers. During this time period they provided training to 562 new recruit fire fighters and 126 advancing fire officers.[82]

The City of New York operates independently from the training programs administered by the New York State Department of State's Office of Fire Prevention and Control (OFPC). The OFPC plans, develops, coordinates and implements training annually to more than 30,000 firefighters in the state, and operates the Senator Frederick L. Warder Academy of Fire Science in Montour Falls, NY.[83] The Warder Academy of Fire Science is accredited through Pro Board and utilizes multiple NFPA professional qualification standards for its fire fighter certifications.

Aiken, South Carolina

The City of Aiken is a smaller sized metropolitan area in South Carolina. The fire department is somewhat unique among fire service organizations in that it is a public safety department that combines the duties of fire and rescue services with law enforcement services. Thus its personnel are cross trained as both fire fighters and police officers. Aiken uses the South Carolina Fire Academy to fulfill its fire service training and education needs.[84]

Fire service training and education is provided statewide in South Carolina through the State Fire Marshal's office under the auspices of the South Carolina Department of Labor, Licensing and Regulation. The South Carolina Fire Academy operates under the State Fire Marshal's Office; it's used by many fire service organizations in the state despite not being mandatory. The Academy's facility located in Columbia, SC is among the most comprehensive state fire training facilities in the United States and is set on an expansive 208 acre campus.[85] The South Carolina Fire Academy is accredited through IFSAC and uses a range of NFPA professional qualification standards for its fire fighter certifications.

Houston, Texas

Houston Texas, like other large metropolitan areas in the United States, has its own extensive internal training and education program. The Houston Fire Department (HFD) training and education activities are handled under the Professional Development Division that operates through the Houston Fire Department Logistics Command.[86]

The Houston Fire Department Professional Development Division functions with a twofold focus: (1) workforce development for new recruits and certain in-service training, and (2) career development for fire officers and other special topics. Workplace training is currently handled through the department's Val Jahnke Training Facility (VJTF) that, among other responsibilities, provides the primary processing center for new recruits. The Officer Development Center (ODC) is a regional initiative that is shared by Houston and certain neighboring jurisdictions, and provides career development for fire officer development and other special topics such as mass casualty training (i.e. large scale disasters with large numbers of victims).[87]

Houston is fortunate to be in the geographic vicinity of the Texas Engineering Extension Service (TEEX), which is a fire service training and education institution that operates as part of the Texas A&M University System. This region of Texas is known for its extensive petrochemical facilities, and this has given rise to recognition at TEEX as a center for excellence for industrial fire protection applications, including hazardous materials oriented training.[88] TEEX is accredited for certifications through both the IFSAC and Pro Board systems.

Statewide fire service training in Texas is administered by The Texas Commission on Fire Protection (TCFP). This is a state government agency with statutory authority responsible for providing resources to Texas fire departments to fulfill critical equipment and training needs. They establish and enforce standards for fire protection personnel training and related topics.[89] The Commission uses multiple NFPA professional qualification standards for its fire fighter certifications and is accredited through the IFSAC process.

Dane County, Wisconsin

Fire departments in Dane County, Wisconsin utilize fire service education and training provided by the Wisconsin Technical College System (WTCS) through 16 technical college districts with 47 campuses throughout the state. These technical college districts include 13 Regional Fire Training Centers capable of live fire training programs in addition to classroom training.[90]

Certain large Wisconsin fire departments also have their own internal training programs, although they still have access to the WTCS system to supplement the selected training activities they handle internally. An example in Dane County is the Training & Safety Division of the Madison City Fire Department. Their internal training programs include special topics such as technical rescue and hazardous materials for specially assigned fire department personnel.[91]

The origins of the WTCS can be traced to 1977 with the creation of a state government oversight group to establish, coordinate and supervise fire service education and training in Wisconsin. Today the WRCS fulfills this function through statuary authority to provide fire

service training to members of volunteer and paid fire departments maintained by cities, villages and towns.[92] Wisconsin Fire Certification is widely used despite being voluntary, and is based on IFSAC accreditation and on several NFPA professional qualification standards. Wisconsin recognizes reciprocity for certifications through both the IFSAC and Pro Board systems.

3) ASSESSMENT OF TRAINING NEEDS

For all topics of interest to fire service emergency responders, an on-going need exists for updated, accurate, consistent, readily understandable and timely training information. This is true for all emergency events that fire fighters are called upon to handle. This includes special topics like emergencies involving hydrogen.

What are the safety infrastructure training needs for applications involving hydrogen? What steps need to be taken to address the practical concerns of emergency responders for hydrogen-based installations such as refueling stations, fixed site fuel cell power supplies, industrial lift trucks, manufacturing facilities, motor vehicle accidents, railway accidents, or pipelines?

Addressing these questions has involved analyzing the requirements of these installations of interest to emergency responders in the preceding sections of this study (see Part 1: *Fire Service Primer* and Part 2: *Permitting Roadmap and Incident Response Protocols*). The fire service information that has been provided allows us to summarize the performance characteristics that are perceived to be currently lacking in order to achieve emergency responder goals (i.e. "needs"). A review of these deficiencies will allow the opportunity to address the most glaring needs for consideration of what should be fulfilled first.

Content Needs for Response Personnel

To be effective, training materials for first responders should address the entire range of hazards associated with hydrogen. This includes not only the obvious hazardous characteristics such as the flammable and explosive properties of hydrogen, but also the secondary concerns such as those associated with the equipment handling the hydrogen (e.g. charged electrical circuits, high pressure storage containers, etc). Fortunately, the hazards associated with hydrogen are similar to other flammable conventional gaseous fuels that are already familiar to the first responder community. This related training information is readably adaptable to similar hydrogen events.

The content of training programs needs to be tailored to fit the intended fire fighter audience. For a specific emergency response topic like an incident involving hydrogen, the amount of knowledge necessary for fire fighters to accomplish their jobs will be different depending on their assigned tasks. For example, a fire fighter who is a new recruit requires a different level of knowledge and training than does a fire officer. For all topics of interest to fire service emergency responders, an on-going need exists for updated, accurate, consistent, readily understandable training information.

Multiple sources of training content are currently available to first responders for emergency events involving hydrogen. First responder training content can be found, for example, through the DOE web portal at hydrogen.energy.gov with their on-line training package "Hydrogen Safety for First Responders".[93] Printed and electronic media is available that includes curricula specific training information published in sources such as Fire Protection Publications (in conjunction with IFSTA), Jones and Bartlett Publishing, and Delmar Learning.[94, 95, 96] Further, it is not unusual for this to be a topic specifically addressed at certain annual meetings such as the Fire Department Instructors Conference (April in Indianapolis) or the IAFC HazMat Conference (May in Baltimore).[97, 98]

Facilities that provide specific training on hydrogen related emergencies exist at several locations. An example of such a center is the DOE "*Volpentest HAMMER Training and Education Center*" in Richland, WA.[99] Other facilities similarly have strong reputations for specializing in hazardous materials training, such as at the "*Center for Domestic Preparedness*" in Anniston, AL, and the Texas Engineering Extension Service at Texas A&M University in College Station, TX.[100, 101] These and other specialized training facilities serve as centers of excellence for training on the topic of hydrogen.

The multiple types of fire fighters, variations of fire departments, different geographic areas, and other factors create a challenging training environment where multi-faceted approaches to content development would likely be most efficient overall. It should not be expected that "one size will fit all". For example, the highly detailed content at a specialized on-site training facility possibly suggests focusing on fire officers or training instructors, while a more efficient approach for reaching the large population of new recruit fire fighters might best be through succinct content delivered via on-line resources with interactive PowerPoint slides and multi-media video.

Content Needs for Prevention/Preparedness Personnel

Training programs for fire service personnel other than emergency first responders are important and deserve special attention. In particular, two important fire service constituent groups who are not normally front-line emergency responders are: (1) fire inspection and permitting officials; and (2) fire training instructors.

Further acceptance of hydrogen based installations within the current permitting infrastructure will benefit by training and education programs for fire prevention personnel such as inspectors and permitting officials. Some current programs offer useful content, but these are not as common as are the training packages for front-line emergency first responders. One example is through the DOE web portal at hydrogen.energy.gov that provides the on-line training package "Introduction to Hydrogen for Code Officials".[102] Expanding the available training programs for fire prevention personnel will directly benefit the proliferation of new installations using hydrogen.

Fire service instructors also require special attention regarding training content. To be effective they require a higher level of understanding and knowledge on the hazards associated with hydrogen than their student body of first responders. The comprehension of detail required by a fire service instructor is generally more involved. Thus a higher level of attention is often given to instructor training programs since these will help assure overall quality instruction for reaching the expansive population of U.S. fire fighters.

The content of training materials for the multiple fire service target audiences requires special development and dissemination consideration to achieve overall effectiveness. This suggests a coordinated multi-faceted strategy rather than a single ideal strategic approach. This would optimize the available resources for out-reach to the approximate 1.1 million members of the U.S. fire service with training information they can best utilize.

Implementation and Partnerships

There are many approaches to the method of delivery for fire service information on any particular topic (e.g. a hydrogen emergency). Each approach has its own positive and negative characteristics which should be considered based on the intended target audience. For example, hands-on-training is generally considered more effective than simulations or distance learning. Conversely, distance learning and similar methods are generally much more efficient for reaching large student populations.

Fire fighters require training for many topics. The challenges of distributing training information oriented toward emergencies involving hydrogen is similar to the challenges of distributing training information on other competing topics. Consequently, training programs need to be as efficient as possible without compromising the effectiveness of the program. One approach to achieving this efficiency is to integrate training on special topics like hydrogen into existing training programs. On-going time away from normal fire department duties to attend dedicated training programs is a challenge for all fire fighters and fire departments. Attending on-site training facilities, even for facilities within a fire fighters home state, is time consuming and can be a challenge for a fire department's limited available resources.

Instructor training (i.e. "train-the-trainer") initiatives are an important concept when trying to facilitate knowledge transfer on a specific topic like hydrogen. These trainers, a.k.a. fire service instructors, need in-depth knowledge to further instruct their students, and they would benefit from on-site training at state-of-the art training facilities (e.g. the Volpentest HAMMER Training and Education Center).[103] In a multi-strategy implementation approach, one aspect might focus toward training-the-trainer as much as possible with on-site training at specialized training facilities, while in parallel another aspect could focus on using a different training delivery strategy for newly recruited fire service personnel (e.g. a condensed interactive on-line training program).

The existing fire service infrastructure is relatively well-established and should be utilized as much as possible through organizational partnerships and collaborations. The optimum development and dissemination of training materials for hydrogen-based installations is most likely to occur through the broadest involvement of applicable organizations. Certain national groups have attributes that make them attractive possible partners for developing and disseminating fire service training information.

Several federal government agencies and national organizations should be considered as possible collaborating partners for developing and disseminating training materials. Among these, the NFA (National Fire Academy) is one group that provides a unique gateway for reaching the fire service with hydrogen-based training information.[104] The NFA is an important point of contact for the centralized development, refinement and dissemination of fire service training materials. Available options include actual training courses delivered on-site at the NFA, and the development "Endorsed Courses" on hydrogen for hand-off through NFA to internal fire department training programs.

Another key group for developing and disseminating training information is the NAFTD (North American Fire Training Directors).[105] Their involvement as a collaborating partner would facilitate the dissemination of specific training information. The NAFTD membership provides an effective network for circulating training materials to fire service personnel in their respective states. Further, they work closely with NFA on various initiatives, including the review of content in certain NFA curricula development efforts.

A concept worth considering is the development of a sophisticated traveling training package that includes portable hands-on props and hardware. If such a travelling hands-on program is established, the NAFTD would be a natural host for its effective implementation. They generally have direct access to the on-site training facilities at the state level within their respective states, and NAFTD member organizations would be able coordinate the circulation of the program within their respective jurisdictions.

Additional partnering organizations should be considered for the proliferation of training packages that address fire service concerns for hydrogen. For example, other federal government organizations have mechanisms for disseminating information (e.g. DOT), and existing hazardous materials training initiatives can be supplemented with content on hydrogen (e.g. TRANSCAER).[106] Certain membership groups should be considered based on their direct access to their extensive memberships, such as with IAFF, IAFC and NVFC. In addition, training programs geared toward a pre-determined audience should involve the specific membership organizations of that constituency, such as NASFM and IFMA for fire prevention personnel, or ISFSI for fire service instructors.

4) PART 3: SUMMARY OBSERVATIONS

This report provides a detailed examination of certain features and characteristics of the fire service in the United States. Specifically, the information contained herein summarizes first responder training venues for applications involving hydrogen-based applications (e.g. road vehicles, rail vehicles, industrial lift trucks, fixed sites, etc).

The goal of this effort is to improve the transfer of hydrogen safety information to and from the fire service. The fire service in the United States does not exist as a homogeneous organization or one that can be reached through a single advocacy organization. This effort provides an overview of the U.S. fire service and information as to how to communicate with the U.S. fire service in key jurisdictions.

The intent of this report is to identify pertinent first responder safety training initiatives and applicable fire service organizations, based on consideration of hydrogen-based applications such as refueling stations, stationary fuel cell power supplies, road vehicles, rail vehicles, industrial lift trucks, etc. It additionally reviews approaches for disseminating training information and provides an assessment of fire service training needs.

The following are specific observations that can be found throughout this report and summarized here for convenience:

<u>Training and Education Programs</u>

- For all topics of interest to fire service emergency responders (including the approximate 1.1 million U.S. fire fighters), an on-going need exists for updated, accurate, consistent, readily understandable training information to perform their jobs in as safe a manner as possible..
- The lessons learned from fire fighter fatality incidents repeatedly indicate warnings that training is insufficient, and point to the need for full-service comprehensive training.
- The two basic sources of training information for fire departments are (1) internal and (2) external to the organization.
- The diverse nature of the fire service suggests that multiple training strategies are needed to address specific target groups.
- Successful training programs need to optimize the wide spectrum of approaches used in the knowledge transfer process (e.g., distance learning is generally more efficient but less effective than hands-on training).
- Baseline professional qualification requirements for the various fire fighter duties are well defined in continually updated national standards.
- Certification programs in many states are voluntary, and states often do not have mandatory minimum qualifications requirements for fire service personnel.

Assessment of Training Needs for Content Relating to Response Personnel

- Training materials for first responders need to address the entire range of hazards associated with hydrogen, including direct hazard characteristics (e.g. flammability, etc) and indirect hazard characteristics (e.g. charged electrical circuits, high pressure storage containers, etc).
- The content of training programs needs to be tailored to fit the intended fire fighter audience (e.g. new recruits require a different level of knowledge and training than do fire officers).
- The challenges of distributing training information oriented toward emergencies involving hydrogen is similar to the challenges of distributing training information on other competing topics.
- Multiple sources of printed or electronic training content are currently available to first responders for emergency events involving hazardous materials including hydrogen.
- Facilities that provide specific training on hydrogen related emergencies exist at several locations.
- Factors such as multiple types of fire fighters, variations of fire departments, and different geographic areas create a challenging training environment where multi-faceted approaches would likely be most efficient overall.

Assessment of Training Needs for Content Relating to Prevention/Preparedness Personnel

- Training programs for other than response personnel are important and deserve special attention, especially for (1) fire inspection and permitting officials, and (2) fire training instructors.
- The diverse and dynamic nature of the fire service requires a coordinated multi-faceted strategy for effectively disseminating training materials, rather than a single ideal strategy.
- Further acceptance of hydrogen based installations within the current permitting infrastructure will benefit by training and education programs for fire prevention personnel such as inspectors and permitting officials.
- Fire service instructors generally require more detailed and in-depth training than other fire service personnel to perform their duties as knowledgeable instructors.
- Fire service instruction programs should include methods for evaluation, not only of the trainees but also for the trainers.
- Initiatives for instructor training need to include the development and implementation of the lesson plans that trainers will ultimately use.

Emergency Response Training Implementation and Potential Partnerships

- The existing fire service infrastructure is relatively well-established and should be utilized as much as possible through organizational partnerships and collaborations.

- Partnering with related federal government out-reach programs should be considered, as well as partnering with national membership organizations for improved access to their constituents.
- Various out-reach models currently exist on other technical topics similar to hydrogen, and these should be considered for the distribution of hydrogen-specific training materials (e.g. “TRANSCAER” outreach of hazmat training materials to emergency responders).
- The National Fire Academy administered by USFA is a central organization for the development and dissemination of training curriculums for the fire service; they should be considered for incorporating specific information into their existing training curriculums, and considered for options such as establishing material used as an “endorsed course”.
- The North American Fire Training Directors is an important conduit for the dissemination of training information to individual state training programs; they would be a natural host for sophisticated traveling training packages that include hands-on props and hardware, based on their direct access to the on-site training facilities at the state level within their respective states.
- NFPA professional qualification standards provide important baseline requirements that define the job task requirements used in fire fighter training programs.
- The two key groups for fire service accreditation and certification are the IFSAC and Pro Board, and they promote widespread systematic implementation of the NFPA professional qualification standards.
- The recent trend is for states and other organizations to obtain accreditation from both IFSAC and Pro Board to provide their certified fire fighters with reciprocity.

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ANNEX A: STATEWIDE ACCREDITATION INITIATIVES

Annex A provides a summary of how each state and the District of Columbia implement their accreditation efforts for the training of fire service personnel. Table 3-4 summarizes the accreditation initiatives that exist in each state and the District of Columbia.

Specifically, Table 3-4 summarizes which of the two accrediting processes (IFSAC or Pro Board) is used by each state, and which NFPA Professional Qualification standards they use. In general, the two accrediting organizations are competitive. Recent years have seen an increase in states obtaining dual accreditation to provide their certified fire fighters with the greatest level of recognition if they transfer between departments in different states. For the jurisdictions in Table 3-4 that have both IFSAC and Pro Board accreditation, certifications may be for some or all of the indicated disciplines.

The information provided is based on the general approach used at the state level, but regional and/or local use may also occur with or without statewide use. Some examples include the Colorado Metropolitan Certification Board, Honolulu International Airport, Fire & Emergency Services (Fort Monmouth, NJ); and Great Oaks Institute (Cincinnati, OH).

Table 3-4: Statewide Accreditation Initiatives (as of July 2008)[107]

STATE	ACCREDITATION	DISCIPLINE	STANDARD	EDITION
ALABAMA	IFSAC Pro Board	Hazardous Materials	NFPA 472	2002 / 200 8
		Fire Fighter	NFPA 1001	2002 / 2008
		Driver/Operator	NFPA 1002	2003
		Airport Fire Fighter	NFPA 1003	2005
		Rescue Technician	NFPA 1006	2003
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Public Fire Educator	NFPA 1035	2005
		Fire Service Instructor	NFPA 1041	2002
		PubSafety Telecommunicator	NFPA 1061	2002
		Fire Dept. Safety Officer	NFPA 1521	2002
ALASKA	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Service Instructor	NFPA 1041	2002
ARIZONA	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Hazardous Materials	NFPA 472	2002 / 2008
ARKANSAS	IFSAC Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Hazardous Materials	NFPA 472	2002 / 2008
		Driver/Operator	NFPA 1002	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
CALIFORNIA	IFSAC	Hazardous Materials	NFPA 472	2002/ 2008
		EMS HazMat	NFPA 473	2002
COLORADO	IFSAC Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Hazardous Materials	NFPA 472	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Fire Service Instructor	NFPA 1041	2002

		Airport Fire Fighter	NFPA 1003	2005
		PubFire/Life Safety Educator	NFPA 1035	2005
CONNECTICUT	IFSAC Pro Board	Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Rescue Technician	NFPA 1006	2003
		Fire Service Inspector	NFPA 1031	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		PubFire/Life Safety Educator	NFPA 1035	2005
		Fire Dept. Safety Officer	NFPA 1521	2002
		Airport Firefighter	NFPA 1003	2005
DELAWARE	IFSAC Pro Board	Hazardous Materials	NFPA 472	2002/ 2008
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Instructor	NFPA 1041	2002
		Wildland Fire Fighter	NFPA 1051	2002
DISTRICT OF COLUMBIA	IFSAC	Driver/Operator	NFPA 1002	2003
		EMS HazMat	NFPA 473	2002
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Fire Dept. Safety Officer	NFPA 1521	2002
FLORIDA	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Instructor	NFPA 1041	2002
		Public Safety Educator	NFPA 1035	2005
GEORGIA	Pro Board	Hazardous Materials	NFPA 472	2002/ 2008
		Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Airport Fire Fighter	NFPA 1003	2005
		Rescue Technician	NFPA 1006	2003
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Public Fire Educator	NFPA 1035	2005
		Fire Instructor	NFPA 1041	2002
		Wildland Fire Fighter	NFPA 1051	2002
		PubSafety Telecommunicator	NFPA 1061	2002
HAWAII	IFSAC	Hazardous Materials	NFPA 472	2002/ 2008
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Instructor	NFPA 1041	2002
		Driver/Operator	NFPA 1002	2003
		Airport Firefighter	NFPA 1003	2005
		Fire Officer	NFPA 1021	2003
IDAHO	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
ILLINOIS	IFSAC Pro Board	Based on State Requirements		
INDIANA	IFSAC	Airport Fire Fighter	NFPA 1003	2005
		Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003

		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
IOWA	IFSAC	Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Fire Inspector	NFPA 1031	2003
		Hazardous Materials	NFPA 472	2002/ 2008
KANSAS	IFSAC Pro Board	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Rescue Technician	NFPA 1006	2003
KENTUCKY	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Airport Firefighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
LOUISIANA	IFSAC Pro Board	Industrial Fire Brigade	NFPA 1081	2001
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Airport Fire Fighter	NFPA 1003	2005
MAINE	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2002
		Fire Service Instructor	NFPA 1041	2002
MARYLAND	IFSAC Pro Board	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		EMS HazMat	NFPA 473	2002
		Fire Dept. Safety Officer	NFPA 1521	2002
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector/Plans Examiner	NFPA 1031	2003
		Fire Instructor	NFPA 1041	2002
		Fire Investigator	NFPA 1033	2003
		Fire Officer	NFPA 1021	2003
		Hazardous Materials	NFPA 472	2002/ 2008
		Industrial Fire Brigade	NFPA 1081	2001
		Public Fire Educator	NFPA 1035	2005
		PubSafety Telecommunicator	NFPA 1061	2002
		Rescue Technician	NFPA 1006	2003
		Wildland Fire Fighter	NFPA 1051	2002
MASSACHUSETTS	Pro Board	Hazardous Materials	NFPA 472	2002/ 2008
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Public Fire Educator	NFPA 1035	2005
		Fire Instructor	NFPA 1041	2002
		Driver/Operator	NFPA 1002	2003

		Fire Dept. Safety Officer	NFPA 1521	2002
		Airport Fire Fighter	NFPA 1003	2005
		Rescue Technician	NFPA 1006	2003
		PubSafety Telecommunicator	NFPA 1061	2002
MICHIGAN		Fire Investigator	NFPA 1033	2003
MINNESOTA	IFSAC Pro Board	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		PubFire/Life Safety Educator	NFPA 1035	2005
		Fire Investigator	NFPA 1033	2003
		Wildland Fire Fighter	NFPA 1051	2002
MISSISSIPPI	IFSAC	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		PubFire/Life Safety Educator	NFPA 1035	2005
		Fire Dept. Safety Officer	NFPA 1521	2002
		Fire Investigator	NFPA 1033	2003
MISSOURI	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
MONTANA	IFSAC Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Service Instructor	NFPA 1041	2002
		HazMat First Responder	NFPA 472	2002/ 2008
NEBRASKA	IFSAC Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
NEVADA	IFSAC	Based on State Requirements		
NEW HAMPSHIRE	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Fire Officer	NFPA 1021	2003
		Fire Instructor	NFPA 1041	2002
		HazMat First Responder	NFPA 472	2002/ 2008
		Airport Fire Fighter	NFPA 1003	2005
		Fire Inspector	NFPA 1031	2003
		Wildland Firefighter	NFPA 1051	2002
NEW JERSEY		Based on State Requirements		
NEW MEXICO	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
NEW YORK	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Fire Investigator	NFPA 1033	2003
		Fire Dept. Safety Officer	NFPA 1521	2002

		Rescue Technician	NFPA 1006	2003
		Fire Inspector	NFPA 1031	2003
NORTH CAROLINA	IFSAC Pro Board	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		PubFire/Life Safety Educator	NFPA 1035	2005
		Rescue Technician	NFPA 1006	2003
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Wildland Firefighter	NFPA 1051	2002
NORTH DAKOTA		Based on State Requirements		
OHIO	IFSAC	Hazardous Materials	NFPA 472	2002/ 2008
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Instructor	NFPA 1041	2002
OKLAHOMA	IFSAC Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Inspector	NFPA 1031	2003
		Fire Officer	NFPA 1021	2002
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
OREGON	IFSAC	Based on State Requirements		
PENNSYLVANIA	IFSAC Pro Board	Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Rescue Technician	NFPA 1006	2003
		Airport Fire Fighter	NFPA 1003	2005
		Fire Investigator	NFPA 1033	2003
		Driver/Operator	NFPA 1002	2003
RHODE ISLAND	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Instructor	NFPA 1041	2002
		Fire Dept. Safety Officer	NFPA 1521	2002
		Driver/Operator	NFPA 1002	2003
SOUTH CAROLINA	IFSAC	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Service Instructor	NFPA 1041	2002
		PubFire/Life Safety Educator	NFPA 1035	2005
		Hazardous Materials	NFPA 472	2002/ 2008
SOUTH DAKOTA		Based on State Requirements		
TENNESSEE	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Instructor	NFPA 1041	2002
		Fire Officer	NFPA 1021	2003
		Hazardous Materials	NFPA 472	2002/ 2008
TEXAS	IFSAC	Airport Fire Fighter	NFPA 1003	2005
		Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Hazardous Materials	NFPA 472	2002/ 2008
		Rescue Technician	NFPA 1006	2003

		Fire Officer	NFPA 1021	2003
		Fire Inspector/ Plan Examiner	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Fire Instructor	NFPA 1041	2002
		PubSafety Telecommunicator	NFPA 1061	2002
		Industrial Fire Brigade	NFPA 1081	2001
		Fire Dept. Safety Officer	NFPA 1521	2002
		Marine Fire Fighter	NFPA 1005	2007
UTAH	IFSAC Pro Board	Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Airport Fire Fighter	NFPA 1003	2005
		Fire Inspector	NFPA 1031	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		PubFire/Life Safety Educator	NFPA 1035	2005
		Wildland Fire Fighter	NFPA 1051	2002
		Rescue Technician	NFPA 1006	2003
		Fire Investigator	NFPA 1033	2003
VERMONT	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
VIRGINIA	IFSAC Pro Board	Hazardous Materials	NFPA 472	2002/ 2008
		Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Airport Fire Fighter	NFPA 1003	2005
		Fire Officer	NFPA 1021	2003
		Fire Inspector	NFPA 1031	2003
		Fire Investigator	NFPA 1033	2003
		Fire Instructor	NFPA 1041	2002
		Rescue Technician	NFPA 1006	2003
		Public Fire Educator	NFPA 1035	2005
WASHINGTON	IFSAC	Fire Fighter	NFPA 1001	2002/ 2008
		Airport Fire Fighter	NFPA 1003	2005
		Fire Investigator	NFPA 1033	2003
		Fire Officer	NFPA 1021	2003
		Fire Service Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Fire Inspector	NFPA 1031	2003
WEST VIRGINIA	IFSAC Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Fire Officer	NFPA 1021	2003
		Fire Investigator	NFPA 1033	2003
		Fire Instructor	NFPA 1041	2002
		Hazardous Materials	NFPA 472	2002/ 2008
		Rescue Technician	NFPA 1006	2003
		Industrial Fire Brigade	NFPA 1081	2001
WISCONSIN	IFSAC	Driver/Operator	NFPA 1002	2003
		Fire Fighter	NFPA 1001	2002/ 2008
		Fire Instructor	NFPA 1041	2002
WYOMING	Pro Board	Fire Fighter	NFPA 1001	2002/ 2008
		Driver/Operator	NFPA 1002	2003
		Hazardous Materials	NFPA 472	2002/ 2008
		Fire Officer	NFPA 1021	2003
		Fire Instructor	NFPA 1041	2002