Code-Compliant Maintenance Facility Modification Training

Hydrogen

Emeryville, CA

May 15, 2018

Introductions: Clean Cities

- The U.S. Department of Energy's (DOE’s) Clean Cities program advances the nation's economic, environmental, and energy security by supporting local actions to cut petroleum use in transportation.
  - Clean Cities has saved more than 8.5 billion gallons of petroleum since its inception in 1993.
  - 100 local coalitions serve as the foundation of the Clean Cities program.
- This series of workshops was supported by a competitively awarded, cost-shared agreement from the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE-EE0007815.

Introductions: Gas Technology Institute

Independent, not-for-profit established to tackle tough energy challenges, turning raw technology into practical solutions.

- Idea
- Market Analysis
- Technology Analysis
- Product Development
- Lab and Field Testing
- Demonstration
- Commercialization

Introductions: Frontier Energy

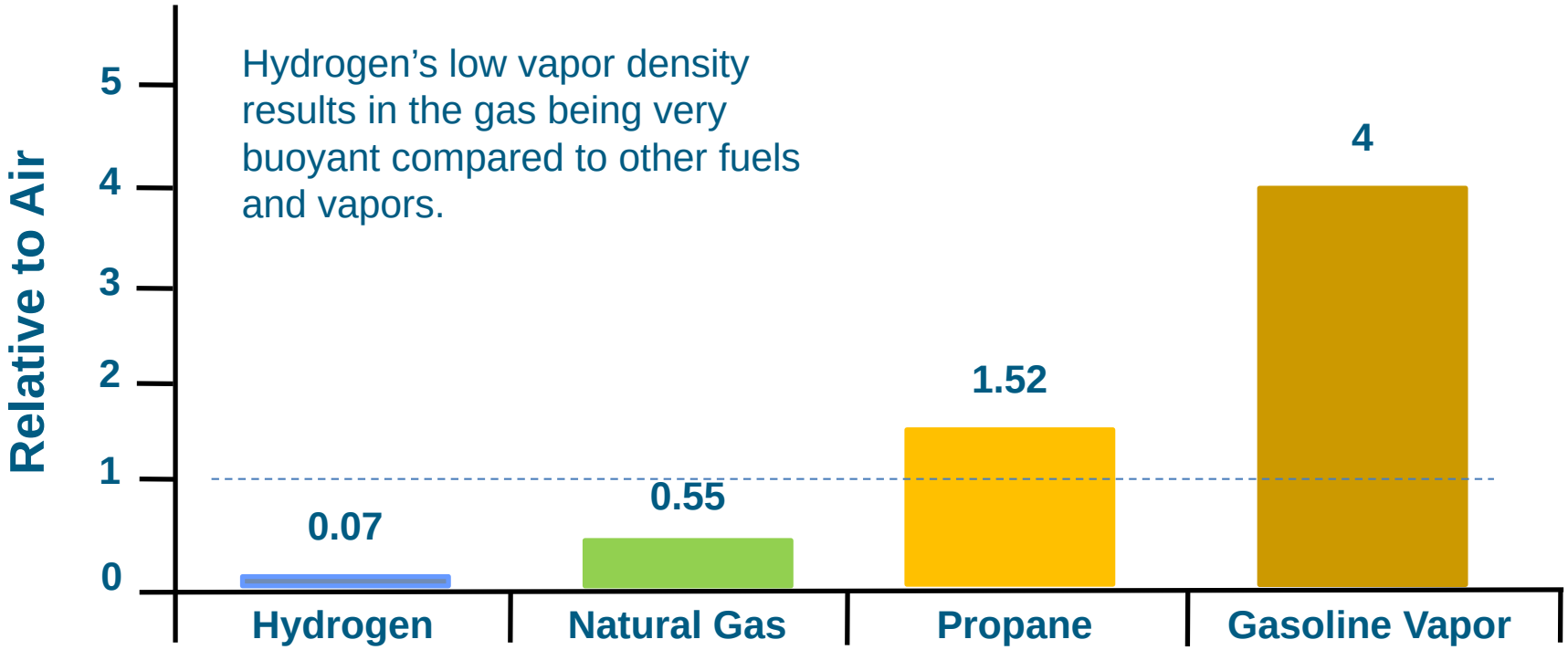
- Frontier Energy was recently formed from five companies in order to leverage strengths, relationships, and data to help reduce energy use, increase alternative transportation, and bring new ideas to life.
- Since 2000, Frontier Energy's Transportation team has provided staffing and management for the California Fuel Cell Partnership, a public-private collaborative recognized worldwide as the epicenter for market introduction of FCEVs and retail hydrogen station.

Goals

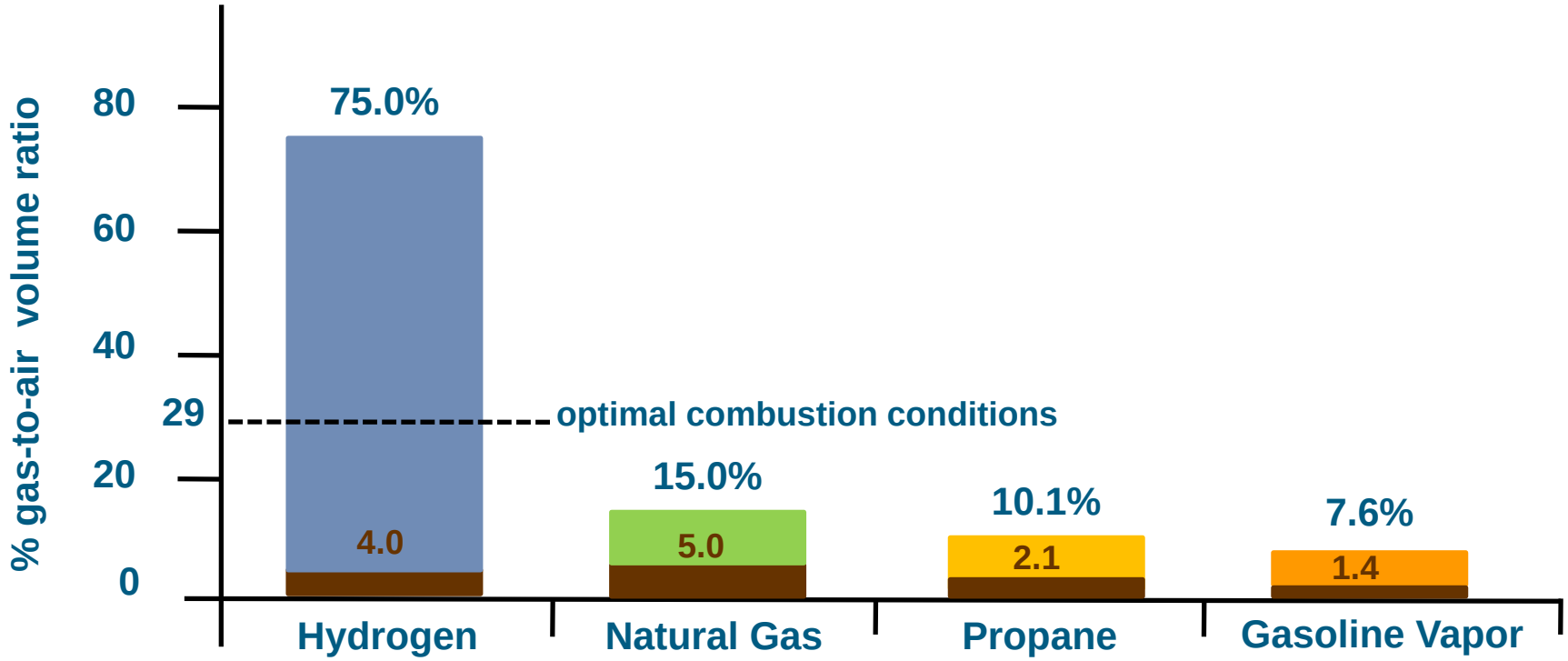
- Applicable Codes and Facility Compliance
- Methods of protection for hydrogen vehicle maintenance facilities
- Fuel Properties and Resulting Effects on Design

Hydrogen Properties

Relative Vapor Density



Flammability Range

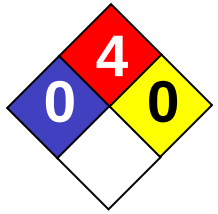
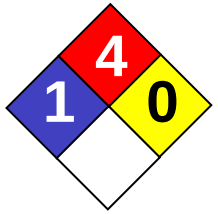
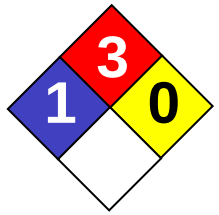


Hydrogen Properties: A Comparison

	Hydrogen	Natural Gas	Gasoline
Color	**No**	**No**	**Yes**
Toxicity	**None**	**Some**	**High**
Odor	**Odorless**	**Mercaptan**	**Yes**
Buoyancy Relative to Air	**14X** Lighter	**2X** Lighter	**3.75X** Heavier
Energy by Weight	**2.8X** > Gasoline	**~1.2X** > Gasoline	**43** MJ/kg
Energy by Volume	**4X** < Gasoline	**1.5X** < Gasoline	**120** MJ/Gallon

Source: California Fuel Cell Partnership

Comparison of Flammability

	Hydrogen	Natural Gas	Gasoline
			
Flammability in air (LFL – UFL)	4.1% - 74%	5.3% - 15%	1.4% - 7.6%
Most easily ignited mixture in air	29%	9%	2%
Flame temperature (°F)	4010	3562	3591

Risk Mitigation

- Just as with any vehicle fuel, the risks of using hydrogen can be mitigated with proper design and procedure practices.
- Codes that govern maintenance garages are written as performance documents, not design documents.
- The aim of any facility risk mitigation plan is to:
  - Reduce potential for leak
  - Quickly address any leak
  - Eliminate ignition sources

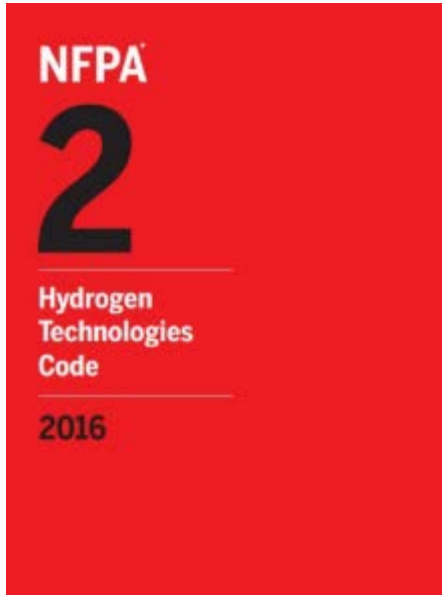
Applicable Codes

Applicable Codes

- This training teaches to the most current versions of the codes in use.
- Your local Authority Having Jurisdiction (AHJ) may not have adopted the most current code.
- Additionally, a local jurisdiction may have additional specific requirements.

Applicable Codes

- Pre-2018
  - NFPA 2: Hydrogen Technology Code
  - NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages
  - International Fire Code
- Post-2018
  - NFPA 2: Hydrogen Technology Code



Major and Minor Garages

Major and Minor Garages

- It is essential to determine what areas of a maintenance facility are considered major and minor, as they will have different requirements.
- A major repair garage is defined as:

  A building or portions of a building for major repairs, such as work on the hydrogen storage system, the fuel cell system, the propulsion system, and repairs that require defueling of the hydrogen fuel cell vehicle, and maintenance or repairs that require open-flame cutting or welding.

Major and Minor Garages

- A minor repair garage is defined as:

  A building or portions of a building not used for work required to be performed in a major repair garage, such as lubrication, inspection, and minor automotive maintenance work, fluid changes (e.g., brake fluid, air conditioning refrigerants), brake system repairs, tire rotation, and similar routine maintenance work.

Major and Minor Garages

Real-World Major vs. Minor

- Fast-Service Oil Change?
- Tire Center?
- Paint Shop?
- Body Shop?
- Dealership Garage?
- OEM Regional Service Center?
- Public Transit Garage?

Real-World Major vs. Minor

- Fast-Service Oil Change - Minor w/liquid fuels
- Tire Center - Minor w/liquid fuels
- Paint Shop - Minor w/liquid fuels
- Body Shop – May be major if welding occurs
- Dealership Garage – Major w/liquid fuels
- OEM Regional Service Center – Major w/liquid fuels
- Public Transit Facility – Major w/liquid fuels

Defueling

- Defueling vehicles to **less than 200 standard cubic feet (SCF)** and sealing the fuel supply will allow a facility to be classified as minor.
- This change does not apply to facilities that do fuel storage system repairs or when welding is done near the fuel container.

Minor Garage Requirements

Minor Garage Requirements

- A minor garage that is already up to code to service gasoline or diesel vehicles is likely already compliant with NFPA 2.
- Adding hydrogen service to existing services may not require any modifications.
- The facility will still need to adhere to general safety requirements of diesel and gasoline garages, including:
  - Sprinklers
  - Heating
  - Ventilation

Minor Garage Requirements

- Sprinklers
- Heating
- Defueling

Heating

- NFPA 2 uses the same requirements for heating devices as NFPA 30A.
  - Heaters with surfaces under 750F are compliant for all fuels.
  - This includes radiant heating, infrared, and certain closed-tubed designs.
  - Intake air for heaters should come from outside the facility, where there will not ever be any hydrogen.

Heating

- Hydrogen readily disperses, and careful attention should be given to any appliance that may be a source of ignition.
- Open-flame heaters and electric heating elements can ignite a hydrogen release, so devices like this should be moved out of hydrogen service areas.

Defueling and Venting

- NFPA 2 requires that the discharge of hydrogen from vehicle fuel storage tanks is vented to atmosphere.
- The vent must be in a safe location, where the fuel can dissipate away from ventilation intakes and ignition sources, in accordance with CGA-G-5.5, Hydrogen Vent Systems
- The defueling equipment should be isolated from other uses, and should not connect with another venting system before discharging to the atmosphere.

Defueling and Venting

- The defueling system needs to include a method of grounding to prevent any static discharge while defueling.
- The defueling nozzle needs to be bonded to ground during defueling as well. Equipment supplied by the vehicle manufacturer shall be used to connect to the vehicle fuel supply containers to be defueled.
- The IFC has one specific requirement that vent pipes have an inner diameter of at least one inch, and the flow through the pipe is limited to 1,000 cubic feet per minute.
- A helpful resource for approval is the Hydrogen Equipment Certification Guide, located on h2tools.org https://h2tools.org/hsp/safety-resources

Major Garage Requirements

Major Garages

- Defueling -> back to minor garage
- If welding or performing open-flame operations within 18 inches of the fuel system, major garage requirements apply.
- A general strategy of detection, dilution, and extraction should be employed.

Detection

Gas Detection

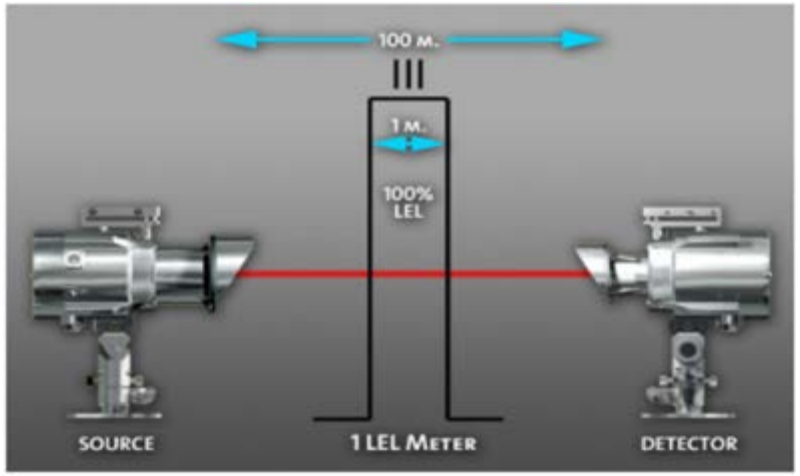
- Major repair garages need a hydrogen gas detection system. This detection system should provide coverage of the vehicle service area.
- Sensors should be located at inlets to exhaust systems, high points in service bays, and inlets to mechanical ventilation systems.
- An integrated alarm system should activate when hydrogen levels are above 25% of the lower flammable limit, essentially at 1% hydrogen in air.

Gas Detection Systems

- The primary functions of a combustible gas detection and alarm system are to:
  - Provide early warning to occupants that a hydrogen gas release has occurred
  - Initiate actions to eliminate potential ignition sources
  - Initiate actions that provide conditions to promote quick dilution of the concentrated gas to levels below the LFL

Gas Detection Systems

- There are two types of combustible gas detectors: infrared and catalytic bead.
  - Infrared detectors are available as either a point-type monitor or an open-path design.
  - Catalytic bead detectors are not recommended because they require more frequent calibration and have a shorter life before internal components must be replaced.



Gas Detection Systems

- Generally, combustible gas detectors:
  - Should be near the highest point of the structure's ceiling.
  - May be at intermediate locations to "intercept" the likely path that a vapor release would take as it rises to the high point.
- The number, location, and spacing of detectors must be determined by a licensed design engineer and approved by the AHJ.
- Because the gas detectors are located on or near the structure's ceiling, it is important to select detectors that are equipped with a calibration means that does not require direct access.

Ventilation

Ventilation

- Both NFPA 30A 2015 and IFC use ventilation as a primary strategy to prevent hydrogen accumulations at concentrations within the combustible range.
  - Sufficient ventilation is necessary to quickly and effectively **dilute** release so that the concentration is below the combustible level.
  - Ventilation prevents a release from accumulating near potential ignition sources through **extraction**.

Hybrid Ventilation Requirements

AHJ's may require either IFC or NFPA 30A be met, but sometimes they adopt a hybrid approach. In most cases, compliance options are:

- Ventilate Continuously
  - Expensive to do in colder climates. Often the lowest-cost, no-modification strategy in warmer climates.
- Relocate/Replace Hazards
  - Still need to ventilate intermittently
  - Often the best option in colder climates
  - Depending on age and number of devices in classified zone, this may be cost-effective.

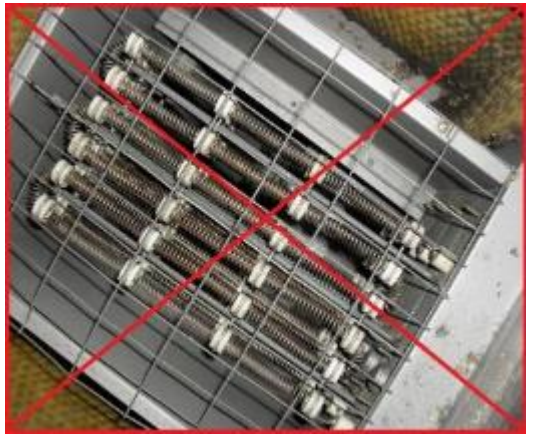
Equipment

Electrical Devices

- Within 18 inches of the ceiling is a Class I, Division 2 area.
- Electrical appliances must be either explosion proof or relocated out of this area.

Heat Producing Appliances

- heaters with surfaces above 750F shouldn’t be permitted in areas where gas may be
- Gas-fired fan-type heaters are not compliant because of their inherent open flames
- Forced air heating systems present a hazard if gas is mixed with makeup air to the unit.



Sparking Equipment

- Equipment that could produce a spark should be located in areas where gas is unlikely to be present.

Welding and Open Flames

- Operations that require open flames or electric arcs or procedures that require cutting that may produce sparks may be sources of ignition in the unlikely event of a leak.
- This type of work should take place in specific areas dedicated to these operations.
- The fire protection precautions should comply with NFPA 51B, but if the garage already complies with NFPA 30A requirements, no modifications should be necessary.

Best Practice: Bay Isolation

- It is common practice to isolate a hydrogen service area so that additional code requirements are applicable to a smaller square footage.
- This area needs to be sealed from gas migration – both hydrogen escaping and other fuels entering.
- This area may need gas detection and alarm systems and may also need separate ventilation.

Best Practice: Alternate Means and Methods

- If the jurisdiction has not adopted the most recent version of NFPA 30A or the IFC, there is usually a provision for using alternate means and methods (AMM).
- This is up to the AHJ to allow, and the project proponent must have justifiable and verifiable changes based on the most recent versions of applicable codes.
- Best practices for getting approval for alternate means and methods include:
  - Work with the AHJ(s) early; have them be a part of the process.
  - Do a pre-submittal meeting with the jurisdiction (while it's not a requirement, it is usually an option).
  - Completely justify compliance of the plan by documenting how you meet latest codes and submit a complete permitting package (the pre-submittal meeting will aid in this, as well).

Disclaimer

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