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Safety Considerations for Maintenance Facility

This document is not intended to identify requirements or regulations, but rather to provide a discussion about facilities, safety issues, and items that should be considered when building or upgrading facilities for hydrogen fueled vehicles.

The transit properties have normally little or no experience with hydrogen fuel.

In each case, a comprehensive site survey needs to be conducted prior to parking or maintaining the hydrogen fueled vehicles indoors.

Since there are no established standards and transit properties' limited knowledge about hydrogen, the transit properties should consult with a reputable safety consultant, professional building contractor, and local authorities to determine the scope of changes required for the facilities to safely operate hydrogen fueled vehicles.

Fire Safety Properties of Hydrogen and Other Automotive Fuels

- 10 times lighter than air
- Wide flammability range: 4% to 74% in air
- Explosive when confined
- Colorless and odorless
- Hydrogen flame is invisible to human eye in sunlight
- Due to its molecular size, hydrogen has a propensity to leak.

Fire Safety Properties of Hydrogen and Other Automotive Fuels

	Hydrogen	Gasoline	Diesel (#2 - Low Sulfur)	Methane (CNG)
Autoignition Temperature	(500°C)	(257°C)	(250°C)	(537°C)
Autoignition Energy in Air	0.02 mJ	0.24 mJ	N/A	N/A
Flame Temperature in Air	(2045°C)	(2197°C)	N/A	(1918°C)
Lower Flammable Limit	4%	1.4%	0.6%	5%
Upper Flammable Limit	74%	7.6%	5.5%	15%
Buoyancy: Gas or Vapor Density Relative to air (at STP)	0.07	2 to 4	4 to 5	0.6
Boiling Point at 1 atm.	(-252°C)	(25 to 225°C)	(180 to 345°C)	(-162°C)

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1 Concept & Goals

Some basic safety engineering design goals should be considered when designing facilities for hydrogen:

- Prevent the formation of ignitable concentrations of hydrogen
  - Eliminate the possibility of hydrogen being leaked in a facility (vehicle storage system dependent).
  - Capability to increase the ventilation rate to dilute any leaked hydrogen to well below its flammable limit.
  - Install tank PRD vent lines from bus to facility venting (based on city and country regulations)
- Add leak detectors and alarms.
- Remove all sources of ignition in the facility
  - Electrical system
  - Infrared or fuel-fired heaters
  - Spark-producing operations, e.g., welding, grinding
  - Personnel activities, e.g., smoking.
- Add signs to warn of potential fire hazards
- Make considerations for environmental protection (e.g., freeze protection).

2 Structural / Architectural Considerations

Indoor facilities should be designed with:

- No confined spaces that may accumulate hydrogen
- Flat ceiling with no traps, cavities, or deep ridges that may accumulate hydrogen
- Non-combustible roof materials
- Fire rated walls
- Explosion or deflagration venting.

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3 Gas Detection Considerations

- Flammable gas detection system, calibrated for hydrogen
- Designed to activate at a predetermined level of detection (e.g., 25 percent of lower explosive limit)
- Initiate warning (e.g., audible and visual alarms)
- Deactivate potentially hazardous systems (e.g., heating system, non-emergency electrical equipment)
- Activate mechanical ventilation system
- Provided with back-up power supply
- Fail-safe design (i.e., failure activates mechanical ventilation and deactivates other systems)
- System install to ensure ease of maintenance and calibration.

4 Electrical Considerations

- Electrical equipment in immediate vicinity of ceiling suitable for locations similar to those of NFPA Group B, Class I, Division 2 (explosion-proof).
- Grounding system for the vehicle.

5 Ventilation System Considerations

- A ventilation system dedicated to mitigating the leak hazard, independent of the heating and air conditioning systems
- Coordinated activation with the gas detection system
- Circulate only fresh make-up air
- Motors and other electro-mechanical equipment suitable for locations similar to those of NFPA Group B, Class I, Division 2
- Back-up power
- Manual switching capability

6 Hydrogen safe facilities in operation Europe and USA

- Hamburg FFG, Germany
- Aberdeen, Scotland
- London, UK
- Oslo, Norway
- Antwerp, Belgium
- Palm Desert, USA
- San Fransico, USA
- Boston, USA

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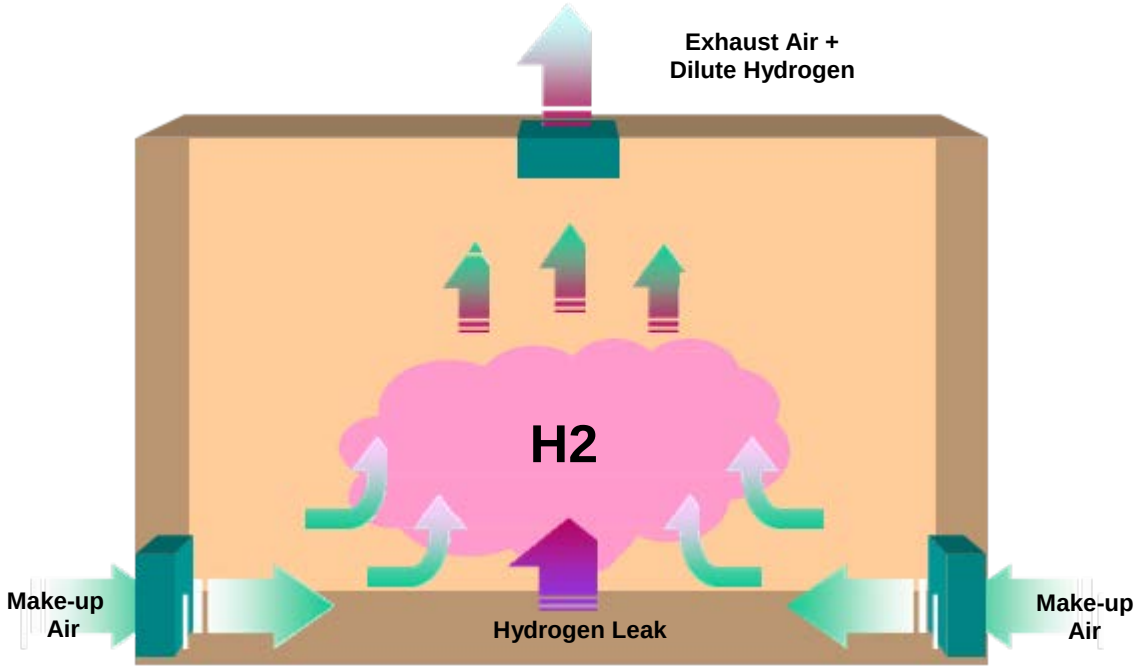
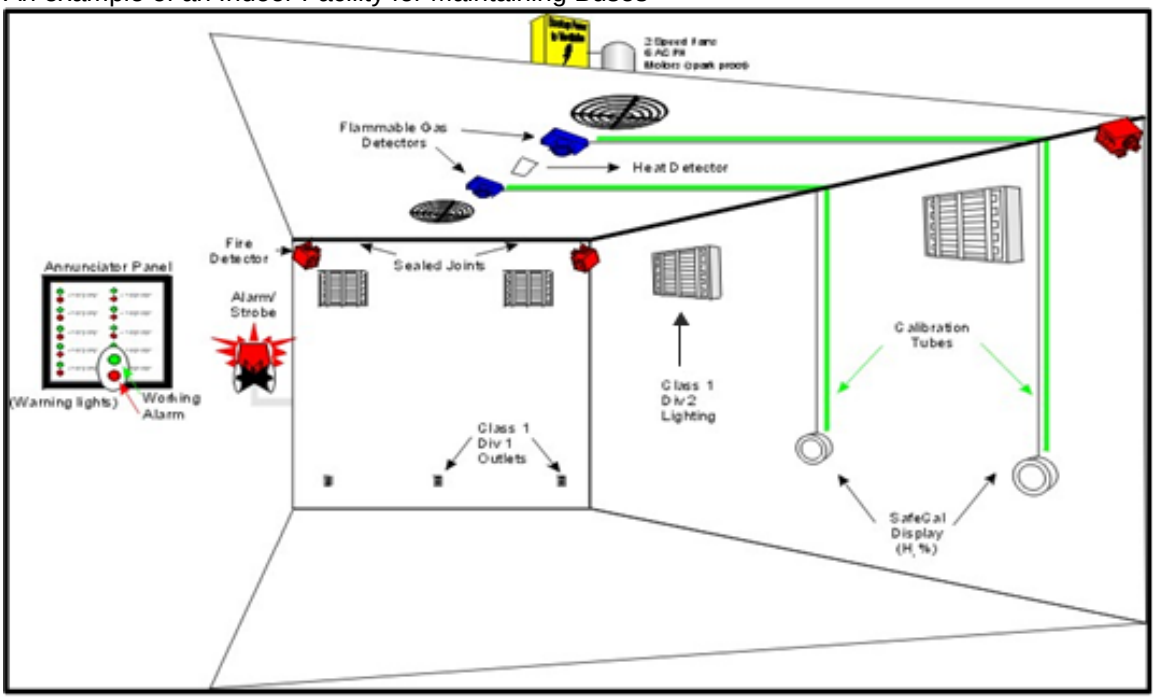
Prepare a ventilation model to ensure adequate airflow is provided for various leak scenarios.



An example of an Indoor Facility for Maintaining Buses



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SUMMARY

- The key to safely operating and maintaining fuel cell vehicles is understanding and mitigating potential hazards associated with hydrogen.
- Although use of hydrogen as a fuel is not a new concept, it is relatively new to urban transportation.
- The main safety goal for hydrogen facilities is to prevent leaks and the formation of ignitable concentrations.
- In the event of a leak, safeguards should be in place to prevent any catastrophic situations.
- Training is required to decrease the likelihood of hazardous situations within operations and maintenance facilities.
- Routing of the fuel cell bus may also be an important safety consideration.