MODULE 10:

Maintenance and Fueling Facility Guidelines

College of the Desert

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The Fuel Cell Engine Company


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MODULE 10: MAINTENANCE AND FUELING FACILITY GUIDELINES

CONTENTS

10.1 Maintenance Facility Guidelines 10-1
10.1.1 Leak Detection Systems 10-1
10.1.2 Fire Detection Systems 10-2
10.1.3 Electrical Classification For Hazardous Locations 10-3
10.1.4 Positive Ventilation 10-3
10.1.5 Emergency Stop Equipment 10-3
10.1.6 Designated Parking and Storage 10-4
10.1.7 Heating Equipment 10-4
10.2 Fueling Facility Guidelines 10-5
10.2.1 Mechanical Design 10-5
10.2.2 Electrical Design 10-7
10.2.3 Clearances 10-7
10.2.4 Safety Provisions 10-7
10.2.5 Materials 10-8
10.2.6 Security 10-8
10.2.7 Maintenance 10-9
10.2.8 Liquid Hydrogen Fueling Facilities 10-9

MODULE 10: MAINTENANCE AND FUELING FACILITY GUIDELINES

OBJECTIVES

At the completion of this module, the technician will:

- understand safety guidelines for hydrogen safe maintenance facilities
- understand safety guidelines for hydrogen fueling facilities

Key Points & Notes

10.1 Maintenance Facility Guidelines

The maintenance facility guidelines detailed in the following sections are representative of those used in current fuel cell bus applications and are intended as guidelines only. Specific guidelines may vary depending on facility location and application. At all times, the maintenance facility must conform to all pertinent government regulations and comply with all local, state and federal building codes and hydrogen related regulations.

Maintenance facilities for hydrogen fueled buses must include:

- leak detection systems
- fire detection systems
- electrical classification for hazardous locations
- positive ventilation
- emergency stop equipment
- designated parking and storage areas
- ignition-free space heating equipment

The specifications for each guideline are detailed in the following sections.

10.1.1 Leak Detection Systems

The facility must include appropriate hydrogen gas leakage detectors with a minimum of two detector heads mounted over the maintenance area. These detectors must be interlocked with the facility so that:

Upon detection of 20% LFL hydrogen:

- an audible alarm sounds inside and outside the maintenance area
- a red light flashes inside and outside the maintenance area
- a 20% LFL alarm sounds and indicator light illuminates at the monitoring station
- all gas supplies shut off
- all bay doors open
- room ventilation increases from 6 to 12 air changes/hour

Upon detection of 40% LFL hydrogen (as above, plus):

- a 40% LFL alarm sounds and indicator light illuminates at the monitoring station
- all electrical power to the test lab is disconnected, with the exception of the ventilation fan and other explosion proof equipment (such as emergency equipment, lights and signs)
- the fire department is notified automatically

- the fire alarm sounds for building evacuation

The leak detection system *on-board* the bus may not be operational during parking or maintenance activities.

Hand-Held Leak Detectors

Portable hand-held hydrogen leak detectors should be accessible at the indoor maintenance and parking areas. Hand-held leak detectors are used for routine leak tests, and can locate small leaks that do not trigger the facility leak detection system.

Emergency Response Plan For Hydrogen Leaks

A proper written response plan for various sizes and locations of hydrogen leaks must be part of the facility's safety plan. The plan should include evacuation plans for personnel within and nearby the facility, and the safe withdrawal of all compressed gas buses. Other responses to a gas leak may include opening the bay doors, increasing the ventilation fan rate, alerting or evacuating other personnel, ceasing nearby operations, moving the bus outdoors, etc.

The length of time that a hydrogen fueled bus can be run inside the facility should be limited as larger quantities of gas may be released when the bus is operating. Repairs should not be carried out in an area designated for parking only.

10.1.2 Fire Detection Systems

The facility must include appropriate fire (IR- or UV-type) detectors, with a minimum of two detector heads mounted over the maintenance area. These detectors must be interlocked with the facility so that:

Upon fire detection for <15 seconds:

- An audible alarm sounds inside and outside the lab area
- A red light flashes inside and outside the lab area

Upon fire detection for >15 seconds, as above, plus:

- All gas supplies shut off
- All electrical power to the test lab is disconnected, with the exception of the ventilation fan and other explosion proof equipment (such as emergency equipment, lights and signs)
- The fire department is notified
- The building is evacuated (fire alarm sounds)

Proper maintenance facility fire detection systems are essential.

Key Points & Notes

Flammable gas mixtures of hydrogen in air are easily ignited by electrical discharges or other ignition sources. Once ignited, a hydrogen flame is almost invisible in daylight due to the absence of soot.

The fire suppression system *on-board* the bus may not be operational during parking or maintenance activities.

Emergency Response Plan For Hydrogen Fires

A proper written response plan for various sizes and locations of hydrogen fires must be part of the facility's safety plan. The plan should include evacuation plans for personnel within and nearby the facility, and an appropriate fire fighting strategy for the emergency response team.

10.1.3 Electrical Classification For Hazardous Locations

All electrical equipment and machinery that have a potential for exposure to hydrogen should conform to NFPA 70, National Electrical Code requirements. According to NFPA 50A, all equipment within 15 ft (4.6 m) of hydrogen equipment must be classified Class I, Div 2. All equipment within 4.9 ft (1.5 m) must be classified Class I, Div 1.

In the US, the electrical installation must conform to the National Electrical Code, Article 500 and supplements pertinent to "Hazardous Locations: Class 1 Installations".

In Canada, the electrical installation must conform to the Canadian Electrical Code Part 1, Section 18, which describes electrical equipment classification for hazardous locations.

In general, these classifications dictate that all electrical power must be interrupted during a facility alarm condition except power that feeds explosion proof equipment.

10.1.4 Positive Ventilation

A maintenance facility must have positive ventilation that can operate at a normal rate of 6 air changes per hour, and increase automatically to 12 air changes per hour when hydrogen is detected. Ventilation flow should be designed such that any hydrogen leaks is exhausted to the outside without dispensing throughout the maintenance shop or accumulating below the ceiling.

10.1.5 Emergency Stop Equipment

The facility must have an automatic emergency stop capability to shut down all facility hydrogen flow and electrical power. At least one emergency stop button should be located away from the immediate shop area so that personnel can evacuate the area in an emergency prior to pressing the button.

Key Points & Notes

10.1.6 Designated Parking and Storage

Key Points & Notes

Indoor areas where a hydrogen fueled bus is parked *while fueled* must contain the same hydrogen safety equipment described for maintenance facilities. In addition, vehicles fueled with liquid hydrogen must be attached to a dedicated vent so that any fuel bleed-off discharges directly outdoors. Indoor parking or maintenance bays should be situated to make it easy to quickly move the vehicle outdoors should a leak occur.

Any vehicle that is known to be leaking hydrogen must not be brought indoors.

Outdoor areas where the bus is parked *while fueled* must be free of sources of ignition (such as operating electrical equipment) and overhead obstructions (such as wires or overpasses).

The bus can be parked in any indoor or outdoor location provided the fuel storage system has been vented to 10 psig (0.7 barg). This slightly above atmospheric pressure prevents air from entering the system. As a matter of course, the fuel storage system should always be vented if a vehicle is stored for one month or longer.

10.1.7 Heating Equipment

Facility heating equipment must not use electrical elements, generate sparks, or present open flames within the electrical classification area. This applies equally to systems used to heat the facility at large, and local systems used to prevent the fuel cell stacks from freezing (whether indoor or outdoor). To comply with this, heat must be ducted into the area using hot air, hot water, or steam. No surface should exceed 800 ºF (426 ºC).

10.2 Fueling Facility Guidelines

Key Points & Notes

The fueling facility guidelines detailed in the following sections are representative of those used in current fuel cell bus applications and are intended as guidelines only. Specific guidelines may vary depending on facility location and application. At all times, the fueling facility must conform to all pertinent government regulations and comply with all local, state and federal building codes and hydrogen related regulations.

The fueling facility must be located outdoors away from any operating electrical machinery or overhead wires. A weather awning or structure over portions of the fuel dispensing area is allowed, provided it does not interfere with the venting or diffusion of hydrogen gas.

Fueling facilities for hydrogen fueled buses must provide:

- appropriate mechanical design
- appropriate electrical design
- adequate clearances
- adequate safety provisions and equipment
- appropriate use of materials
- appropriate security arrangements
- appropriate maintenance procedures

The specifications for each guideline are detailed in the following sections.

10.2.1 Mechanical Design

For safe operation, the mechanical design of the fueling facility must meet the following guidelines:

- The dispensing hose, compressors, tanks, piping manifold and other hydrogen containing portions of the fueling facility must be grounded together by a dedicated cable.
- During fueling, the fueling facility dispensing equipment and the bus must be grounded together using a dedicated cable. A positive grounding interlock system may be used to prevent access to the bus fueling receptacle until a positive ground connection has been made.
- Check valves must be installed within the fuel dispensing station and inside the bus fill port to ensure that there is no backflow during any transfer of hydrogen.
- All storage tanks must have pressure relief devices that release on overpressure or when exposed to fire.
- The compressors must be explosion proof and designed for hydrogen compression.

- The lines from the compressor, storage tanks and bottles must have automatic fast closing valves and manual shutoff valves at both the storage and dispenser ends.
- The fuel dispenser must have a breakaway connection on each hose that limits the breakaway force to 150 lb (660 N). A manual isolation valve must be installed immediately upstream of this breakaway connection. A bleed-off device must be located between the manual isolation valve and the breakaway connection. The breakaway connection must incorporate double shutoff features that isolate both sides of the connection when uncoupled.
- The excess-flow and normal hydrogen shutoff valves at the fueling station should be positioned and anchored so that they will not be disturbed if the fuel hose and/or piping are strained or torn apart.
- Hoses must have retractors or counterweights to prevent fueling connections from hitting the ground.
- The fueling receptacle must be approved for hydrogen use.
- The fueling receptacle must have a sealed vent-back connection. This connection must be designed to convey the vent gas to a safe area. The hose or pipe used in this line must de-couple so that it cannot interfere with the breakaway on the dispenser hose.
- The fueling system (hoses, lines and receptacle) must prevent the entry of air into the vehicle fuel system and fueling station equipment.
- Fuel transfer must be automatically interrupted when the bus fuel tank contains low-pressure (15 psig; 1 barg). Low tank pressure may indicate that the tank contains air. The pressure relief device may have leaked the hydrogen out of the tanks and air may have diffused into the tanks.
- The fuel dispenser must have a temperature compensation system. This system must either adjust the fill pressure to compensate for variations in ambient temperature and the heating of the tanks during fueling, be calibrated to prevent tank overtemperature, or operate with reference to a temperature transducer located inside one of the bus tanks.
- The fuel dispenser must automatically shut down when the vehicle storage system is full and must prevent tank overpressure at all temperatures.
- Automatic electronic systems must interrupt fueling both during overtemperature or overpressure conditions (as above) or during other fueling station faults. The automatic shutdown must interrupt all electrical power to the fueling apparatus including compressors and other equipment.
- The fueling station must include a vent provision capable of discharging the entire contents of the vehicle fuel storage to the atmosphere in a safe location and manner. The fueling station may include an optional defueling system, capable of capturing the hydrogen for re-use.

Key Points & Notes

- All safety relief valves vent ports must discharge in a safe location and manner.
- The structural foundation must be adequate to support all components including the bus. The fueling area must be level.

10.2.2 Electrical Design

For safe operation, the electrical design of the fueling facility must meet the following guidelines:

- All electrical equipment and machinery that have a potential for exposure to hydrogen should conform to NFPA 70, National Electrical Code requirements. According to NFPA 50A, all equipment within 15 ft (4.6 m) of hydrogen equipment must be classified Class I, Div 2. All equipment within 4.9 ft (1.5 m) must be classified Class I, Div 1.
- Electrical equipment that produces sparks may not be used. Unclassified electrical equipment must be located away from the fuel dispensing and fuel delivery equipment.
- All hydrogen-bearing equipment and all electrical equipment must be grounded to the facility (including the dispensing station and hose).
- A lightning arrestor must be connected to the facility. The cable and its footing must be correctly sized to ensure proper grounding.
- Electric and open flame heaters may not be used. Any required heat must be supplied convectively by way of hot air, hot water, steam or some other indirect method.

10.2.3 Clearances

The fueling facility must include the following clearances:

- The facility may not be located under overhead wires, roadways or other obstructions.
- The facility must provide adequate space to access the bus.

10.2.4 Safety Provisions

The fueling facility must include the following safety features:

- The fueling facility must be outdoors.
- No ignition sources may be present at any time.
- An infrared or ultraviolet flame sensor is required in the vicinity of the fueling facility. The flame sensor must interrupt all electrical power to the fueling apparatus and shut off the gas flow when triggered.
- Emergency stop buttons are required at each fuel dispenser and at each exit from the fueling area.

Key Points & Notes

Key Points & Notes

- Only non-sparking tools may be used to operate or maintain the facility.
- Fire extinguishing equipment and procedures must be in place.
- All personnel must be trained in emergency procedures and an evacuation plan.
- A fueling and maintenance record must be kept.
- All certifications and permits must be in place.

Regulatory signs must be included as required. In the absence of specific regulations, signs should indicate:

- that no smoking is permitted at any time
- that the bus must be grounded to the fueling facility and the ignition must be off
- that only non-sparking tools are permitted
- the location of fire extinguishers
- the location of the emergency stop buttons
- the location of manual shutoff valves

10.2.5 Materials

The fueling facility must use materials that are non-combustible, resistant to hydrogen embrittlement and compatible with fuel cell systems. Specifically:

- Materials must meet fuel cell system requirements as detailed in Section 7.1.5.
- Hoses must be made of synthetic material with stainless steel braid and be certified for compressed hydrogen gas use. Hoses must be electrically conductive. The hose ends should be installed by the hose manufacturer and the hose assembly must be pressure tested to 1.5 times the rated pressure. Hoses should be documented with serial number, test pressure, test date and first date of service.

The design of hydrogen facilities should include use of low tensile strength steels wherever possible, proper annealing and welding procedures, and the avoidance of notches, rapid temperature changes, and temperature excursions above and below ambient temperature wherever possible.

10.2.6 Security

The fueling facility should provide adequate security.

10.2.7 Maintenance

Key Points & Notes

The fueling facility instruments and equipment must be regularly maintained. A maintenance record must be kept. This maintenance should include, as a minimum:

- regular testing and calibration of hydrogen flame detectors.
- regular testing and calibration of gas dispenser temperature compensation systems.
- regular testing and calibration of gas dispenser excess flow valve.
- regular testing and calibration of low-pressure shut off valve.
- regular testing and calibration of all pressure relief devices.
- regular compressor service as required by the manufacturer.
- regular leak tests.
- regular inspection of all components for damage, wear or corrosion.
- hoses should be discarded after 12 months of use or immediately after any mechanical abuse such as a breakaway incident.

Facilities should undergo regular fire prevention inspections. This fire prevention inspection includes all devices that are commonly inspected in transit garages, such as:

- general condition of automatic sprinkler heads, sprinkler valve assemblies, dry pipe valves and locked valve shutoffs
- yard hydrants, hoses and portable fire extinguishers
- water supplies
- operational verification and readiness of automatic systems
- housekeeping issues, including cutting and welding procedures, smoking regulations and emergency procedures

10.2.8 Liquid Hydrogen Fueling Facilities

A liquid hydrogen fueling facility consists of a liquid hydrogen storage tank, a vaporizer, a dispensing unit, and associated piping, tubing and valves. The purpose of the vaporizer is to generate enough vapor pressure to initiate liquid flow. The dispensing system must include a vapor return line to the liquid hydrogen storage tank.

A liquid hydrogen fueling facility has the same basic requirements as a gaseous fueling station. In addition:

- Special materials and procedures must be used with respect to cryogenic temperatures. Insulation must be non-combustible and provide a vapor-tight seal in the outer covering to prevent air condensation and subsequent oxygen enrichment within the insulation. The insulation and outside shield must prevent attrition under normal operating con-

ditions. Personnel must wear eye protection, gloves and outerwear made of fire resistant clothing designed for use with cryogenic materials.

- Equipment must not be installed above asphalt surfaces or other combustible materials in order to prevent the contact of liquid air with these surfaces. Concrete is ideal. Drip pans are suitable where required.
- Bleed-off gas must vent in a safe manner
- All vent lines must discharge safely without impingement on the storage container, adjacent structures or personnel.
- A high-pressure air or nitrogen supply needs to be available at the dispenser to clean ice and frost from the receptacle. The nozzle's mating surface must be clean and free of dust, frost, or other solid particles before use.
- Air leaks into the liquid systems must not occur. Helium must be used to purge cold liquid systems since all other gases will condense and freeze at liquid hydrogen temperatures.

Key Points & Notes